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THE POTENTIAL FOR USING CANOLA OIL AS A HERBICIDE CARRIER-SOLVENT IN AERIAL SPRAY APPLICATION (PHASE I)

by

K. Yoshida and K. Wallace

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K. Yoshida, Ph.D., Project Leader
K. Wallace, B.Sc. (Hon.), Senior Research Scientist
Indoor Air Quality Program
Environment Sector
Saskatchewan Research Council
30 Campus Drive
Saskatoon, Saskatchewan
S7N 0X1

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INTRODUCTION

The use of vegetable oils, either as adjuvants or carrier material, to replace petroleum-based products in pesticide spray application has become increasingly attractive, with the cost becoming more competitive compared to that of petroleum-based products, the availability of spray application equipment and methods for low volume applications, and the development of new chemicals compatible with low-volume operations.

Active ingredients of most pesticides in technical formulation are not water soluble, therefore, technical grades of pesticides are formulated with oil-based solvents, emulsifiers and stabilizers for use as spray mixtures. Until recently, the oil was always petroleum-based, but there are several commercial products using vegetable oil that have been introduced for pesticide spray application.

Since the cost of vegetable oil is competitive, in particular the price of Canola oil in Saskatchewan, they may be made to replace petroleum-based surfactants, as an evaporation suppressant mixed with water or as a diluent alone with readily available technical formulation.

Vegetable oils as spray adjuvants have certain advantages over petroleum oils: a) They do not exhibit severe, phytotoxicity on crops or plants as compared to petroleum-based adjuvants. b) Because the formulation becomes non volatile, they also tend to produce improved uniformity of coverage on target substances.

One limitation in the use of vegetable oil as a pesticide adjuvant may be due to physical properties which are temperature dependent. Vegetable oils are inherently more viscous than petroleum oils, so careful

adjustment of spray equipment will be required.

On the other hand, with low volume spray application, in particular with the aerial spray application of phenoxy herbicides on cereal crops, it would be feasible to use vegetable oil as the complete carrier. There are important advantages in using vegetable oil as a carrier material: a) Vegetable oil becomes an economical means of pesticide application by using a lesser amount of spray liquid. b) The reduced volume of spray (LV), in particular with aerial applications, reduces the frequency of refills necessary to cover a given area of field, thus providing increased operational safety for a pilot. c) Because of reduced evaporation from droplets after dissemination, the carrier material substantially controls spray droplet drift as compared to water-based spray. d) Lowered surface tension, by adding oil, results in better spreading of spray droplets over target surfaces and promotes uniform coverage and better penetration into the canopy of target plants. e) Vegetable oils have a lesser degree of photodecomposition. f) By using vegetable oils as carrier materials, the spray liquid may become independent from the (adverse) quality of local water.

The disadvantages of vegetable oils as carrier materials seem to be largely mechanical. There have been some problems keeping the spray equipment clean, problems with flow change caused by temperature variations, and problems with foaming and excessive nozzle clogging.

The use of Canola (Brassiea Napus) oil as a fuel additive for diesel engines has been investigated, including the physical properties and chemical composition of canola oil for combustion purposes. (Strayer et al., 1982. Wagner et al, 1982. Zuk et al, 1981). However, almost

no scientific information on these properties of Canola oil are presently available for its use as adjuvant or carrier in pesticide spray application.

The overall objective of the research project is to produce scientific information that is realistic in low volume aerial spraying of phenoxy herbicide in the prairie provinces by combining the applicable properties of formulations determined in the study with existing methods of low volume aerial spray application, so that the feasibility of the use of Canola oil as herbicide spray carrier may be verified.

Specific objectives of this study are: a) to determine the most promising formulations that provide the highest compatibility between Canola oil and technical herbicide formulations on the basis of physical properties relevant to dissemination; b) to investigate the droplet dissemination characteristics from standard spray nozzles under laboratory conditions; c) to study spray droplet deposition and retention on target plants; and finally d) to present recommendations, on the basis of the above studies, about the most adequate combinations of herbicide formulation and spray equipment for full-scale aerial application trials that are anticipated in Phase II of the study.

This report includes a review of studies on physical properties of oil-based spray, the experimental method used in compatibility test, the spray chamber test, the droplet sampling media, and spray retention test. Also produced are the results of the most adequate blending ratio of Canola oil to maintain the original compatibility of technical formulation, droplet emission characteristics of the formulation by conventional aerial spray equipment, and physical characteristics of spray droplet

retention under the msot realistic condition of the prairie provinces.

All investigations were conducted at the Saskatchewan Research Council Laboratory and at a spray research facility of the Department of Agricultural Engineering, University of Saskatchewan. Herbicide compatibility tests were conducted during the May-June period. Spray dissemination tests were done for the most part in July. The retention test continued to mid August to conclude all laboratory experiments. Commercial products of surfactants and emulsifiers were supplied by Atkemix Inc. (Brantford, Ontario). The formulations used on this study are 2,4-dichlorophenoxy acetic acid (2,4-D as iso-octyl ester and dimethyl amine salt formulation).

I. PHYSICAL PROPERTIES OF OIL-BASED SPRAY REQUIREMENT

1. Low Volume Spray Application

The biological activity of foliar applications of pesticides are governed by a number of factors. Among them is the extent to which the spray liquid wets and covers the foliage surface. This governs the final distribution of pesticides over the intended target surfaces. It is possible that the efficiency of spray applications could be improved with a better understanding of the process which governs the wetting of target surfaces by spray droplets.

With systemic herbicides, satisfactory cover is ensured provided the spray liquid is brought into contact with those areas of target plant surface through which the active ingredient is absorbed. In high-volume spray applications, the target plants are sprayed until the surfaces are saturated and excess spray liquid runs off. This loss of spray liquid by runoff may be reduced by low-volume spraying.

With low-volume sprays, the target coverage is not only dependent on the volume of spray applied, but also on the droplet size spectrum, spreading and retention of droplet on target surface, and reaction of liquid from the surface.

Spray application techniques in which the spray volume ranges from 5 to 400 litre/ha may be classified as low volume spraying. The lower dosages, 15-75 litre/ha are commonly encountered in aerial applications. Ultra-low volume application ranges are less than 5 litre/ha (or 0.5 GPA). (Maas, 1971).

2. Physical Properties

1) Chemical Compatibility

Pesticides are frequently formulated as emulsifiable concentrates, or in water-dispersible oils, which consist of the active ingredient of the pesticide and an emulsifier dissolved in a suitable water-immiscible solvent. Such a product should be spontaneously emulsifiable so that mixing with water will immediately produce an emulsion. This apparently simple procedure enables a number of objectives to be achieved, the most important of which is the uniform distribution of small quantities of technical pesticide over large surface areas of the intended target. (Eaton, 1962).

In practice, the formulation of emulsifiable concentrates falls in to two main parts, the relatively simple blending operation used in the manufacturing plants and the vastly more difficult tasks of selecting the necessary emulsifiers and solvents which will confer on the product the desired properties. The manufacturer is concerned that the products should be of uniform quality, inexpensive to produce, non-corrosive to metal containers, safe and inexpensive to transport and store. (Hartley, 1967, Ford, 1974).

When a manufactured formulation of pesticide is mixed with carrier materials or adjuvants, with unknown physical properties, the compatibility of the end product must be examined. The ability of two or more materials to exist in close and permanent association for an indefinite period is defined as compatibility. Liquids (solvents) are compatible if they are miscible in all proportions and do not undergo phase separation on standing.

The compatibility of technical 2,4-D in ester formulation when mixed with a vegetable oil, such as Canola oil, may be easily estimated because the concentrate already contains adjuvant and is manufactured as emulsifiable concentrates. However, when 2,4-D amine formulation is mixed with a vegetable oil, the compatibility becomes a very serious issue. The water contained in the concentrate must interact with the carrier oil to form an emulsion. There are several definitions of emulsion for different purposes, however, there is a definition which is widely accepted in interfacila phenomena. An emulsion is a heterogeneous system, consisting of at least one immiscible liquid intimately dispersed in another in the form of droplets, whose diameters in general exceed 0.1 micrometer. Such systems possess a minimal stability, which may be accentuated by such additives as surface-active agents, finely divided solids, etc. (Becher, 1965).

The classification of emulsions historically used as oil-in-water or water-in-oil (invert) emulsion has become obsolete since a rapid progress in interfacial science has been made. Without a discussion on the stability, no classifications of emulsion are relevant. The theory of emulsion stability involves investigations on the nature of interfacial film, films of mixed emulsifiers, interfacial film and interfacial viscosity, dimensions of the interfacial film, interfacial film and globule size, and spreading coefficient and stability, (Becher, 1965).

A carrier-solvent to be used in LV or ULV spraying is required to have the following characteristics; a) Lower than average volatility. b) Higher dissolving power with the pesticide concentrate, c) Low viscosity, d) Low phytotoxicity, and e) compatibility with the active ingredient.

2) Kinematic Viscosity and Surface Tension

The viscosity of the spray liquid is one of the contributing factors in spray dissemination characteristics. The droplet size spectrum of the spray is significantly affected by the viscosity of spray liquid. The volume median diameter of spray droplets produced by a viscous liquid are larger than one for a less viscous liquid. By modifying the kinematic viscosity of a liquid, it is possible to delay or prevent the formation of smaller (satellite) droplets in the process of break-up and dissemination.

In conventional, water-based herbicide spray, the values of kinematic viscosity varied linearly as a function of concentration of the active ingredient from 0.705 (tap water) to 0.835 stokes in 2,4-D ester formulation and to 0.765 in 2,4-D amine formulation. (Yoshida and Maybank, 1969).

While the viscosity of the liquid controls the droplet size, the surface tension of liquid is also critical in the formation of droplets, particularly in the process of break-up from liquid sheets, ligaments and chain of droplets. The surface tension of the liquid affects the deposition characteristics of impinging droplets on various solid (target) surfaces. The value of surface tension varied from 60.3 to 32.5 dyne/cm for 2,4-D ester formulation and to 35.2 dyne/cm for the amine. (Yoshida and Maybank, 1969). The values of surface tension tends to converge very rapidly at the 2% 2,4-D mixture level.

3) Stability of Mixed Liquid

The stability requirement of the dispersed liquid phase used in

pesticide spraying depends on the type of formulation and equipment. Presently used spray equipment have efficient agitation and recirculating mechanisms so that a relatively low level of stability of dispersed liquid may be acceptable. In aerial spray applications, some situation may arise when spraying is not completed during the day due to meteorological conditions and spray liquid is left overnight. The dispersed liquid must then be stable for up to 24 hours, or at least any phase separation must be readily re-dispersible.

The stability of the emulsion is usually assessed by the time dependent change in the diameter of emulsion particles and viscosity. The size parameter (mean volume diameter) of emulsion varies proportionally with the elapsed time, however, the viscosity parameter varies inversely. For practical evaluation of mixed liquid stability, flip-jar tests are commonly used.

3. Droplet Size Spectra

Herbicide formulations using Canola oil as a carrier is intended for low volume aerial application (10 to 20 litre/ha). For such application, a previous study indicates that the volume median droplet diameter of 2,4-D amine spray produced by a hollow cone nozzle (D4-45) at 250 kPa ranged from 175 to 230 μm. (Maybank et al, 1978).

Since the use of Canola oil as a carrier is to control spray drift caused by droplet evaporation, the droplet size spectra desired for Canola formulation may be at the lower margin of the above size range (150 μm VMD). The size spectra of spray droplets are controlled by the orifice size, nozzle orientation, the viscosity of the spray liquid,

and hydraulic pressure. Spraying of viscous liquid into droplets of equivalent size to conventional aqueous spray might require increased hydraulic pressure.

4. Target Deposition Density

The deposition of spray liquid on the target surface is often expressed as a percentage of the amount of spray liquid that was applied, thus giving the spray recovery in a swath. To determine the amount of deposition or to calculate the deposition density, petri dishes of 150 mm diameter were used in the previous trials (Maybank, et al, 1978).

The value of swath recovery in aerial application of low volume spray tends to reach 70% allowing 30% of sprayed material to drift off the target area. At low volume application of 5 litres/ha (or 0.5 GPA), the deposition density in the swath at 100% recovery may be 50 mg/m^2.

5. Droplet Retention on Target Surface

Spray droplets disseminated by various devices are oriented toward the intended targets creating impaction by directly energizing them, by assistance of another fluid (bi-fluid system), or by creating an electrostatic field. The retention of droplets on the target surface is also dependent on the physical properties of the spray liquid such as surface tension and viscosity, and also physical properties of the target surface such as surfaces with or without cilia and surfaces with or without waxy structure. External factors are; run-off by immediate rain, or dislodging of dried material (crystals) off the target surface by mechanical motion. The rate of retention may be determined by a combination of these factors.

Deposition tests of pesticide spray, using plastic dummy weeds, may produce relative figures of target retention, however, it can hardly produce absolute figures of retention. The retention of spray droplets is usually determined by extracting the mass of herbicide deposited on the intended target and by dividing it by the total mass of herbicide applied in a unit area. The most crucial part of retention for 2,4-D spray with Canola oil carrier would be the effect of rain wash-out.

II. EXPERIMENTAL METHOD

1. Herbicide Formulation Used

Technical formulations used are, 2,4-D amine 500 (dimethyl amine, PCPA Registration No. 11242) containing 500 g of 2,4-D in a litre of concentrate, and 2,4-D LV ester 700 (low volatile iso-octyl ester, PCPA Registration No. 11246) containing 700 g of 2,4-D in a litre of concentrate.

2. Adjuvant or Emulsifier Used

Commercial surfactants (specially developed for vegetable oil spray and distributed by Atkemix Inc., of Brantford, Ontario) identified as Canplus 129 and Atsurf 205, were used with the ester formulations of 2,4-D. The product Canplus 129 was developed for use in vegetable oil/surfactant blends designed to be used as an activator adjuvant and/or pesticide carrier. Its cost in drum quantities is $2.50/kg. It is claimed to be an effective emulsifier for the most popular vegetable oils, namely Canola and soybean oils. The complete solubility in these oils is maintained over a wide range of concentration, time and temperature. For use as a herbicide adjuvant in Canola, a new formula (DD-389) was recommended by the distributor. This formula contains a blend of mono and diglycerides and fatty acids. It has a hydrophile-lipophile balance (HLB) of 3 which means it is a water in oil emulsifier. The CD-389 formula was the most successful for coupling the 2,4-D amine with Canola oil.

The Canplus 129 and Atsurf 205 formulations are known to maintain fluidity and homogeneous appearance when subject to temperatures ranging from -25°C to 50°C, including being subjected to 5 freeze-thaw cycles.

The formulations when stored for over a year at ambient room temperature retained its integrity and emulsifiability (Nicholls, 1984).

Neither Canplus 129 nor vegetable oil/Canplus 129 blend are currently (April, 1984) registered for use in Canada under the PCP Act. Thus Canplus 129 is being offered for evaluation purposes only. Typical properties of Canplus 129 are: low HLB number, classified as a non-ionic surfactant, appearance at 25°C (amber color) specific gravity at 25°C is approximately 1.01, viscosity at 25°C is approximately 200 cps, pour point is below -18°C, flash point is above 149°C, soluble in parafinic oil, Canola oil, soybean oil and most aromatic solvents, and dispersible in water. The vegetable oil/surfactant blends, at the recommended rate, did not cause significant injury to the growing crop when applied post-emergent as an adjuvant from aqueous diluant. However, no phytotoxicity data is currently available as a non-aqueous pesticide carrier (Nicholls, 1984).

Another surfactant used (Atsurf 205) is a sorbitan mono-oleate ester used for industrial grade applications (petroleum additives, some cosmetic uses, etc). Classed as a nonionic surfactant, properties are: reddish brown color, specific gravity at 25°C is ≅ 1.0, viscosity at 25°C ≅ 1200 cps, pour point -18°C, flash point ≥ 149°C, HLB number 4.3. Atsurf 205 is soluble in most mineral oils, vegetable oils, lower alcohols, and chlorinated solvents, is soluble in water and lower glycols.

ATMUL 124 is a mixture of mono and diglycerides used for an emulsifier in the food industry (margarine). This product was used with the 2,4-D amine with some success, although the CD-389 performed much better. The properties of ATMUL 124 are, HLB number (3.5), a water in oil emulsifier, a solid at 25°C with the appearance of ivory white beads, m.p. 62°C

hydroxyl value ≅ 245, total monoglycerides ≅ 62%, flash point ≥ 149°C. ATMUL is soluble above its melting point in isopropyl alcohol, vegetable oils and mineral oil, insoluble in water and propylene glycol. The specification sheets for CANPLUS 129, ATSURF 205 and ATMUL 124 are found in the Appendix.

3. Physical Properties of the Spray Liquid

1) Compatibility

Commercially produced adjuvants or emulsifiers were mixed with 2,4-D tehcnical concentrates (amine and ester formulations) and refined Canola oil with mechanical agitation or by heating to make samples of 100 mL. Then the mixed liquids were allowed to stand for 24 hours in glass jars. The degree of blending was observed after 24 hours by examining any phase separation. The immiscibility (or emulsion stability) of mixed fluid was observed by flipping jars upside down and the interfacial phenomena was recorded by taking close-up color photographs.

2) Surface Tension

The method used is based on DuNoug ring-pull principle adopted by ASTM in standard method D-971. The surface tension meter used was a Fisher model 20 with platinum-iridium ring of 6 cm circumference. Surface tension was determined in room temperature of 20-25°C.

3) Kinematic Viscosity

The method used is the ASTM designation D 445-61 approved in 1960 and revised in 1961 by using capillary type glass viscosity meters.

Cannon-Fenseke viscometers used are type 300-J245 (capillary diameter 1.26 ± 0.02 mm), type 200-M366 (capillary diameter 1.02 ± 0.02 mm) and type 200 - I 719 (capillary diameter 1.02 ± 0.02 mm). Viscometers were immersed in a constant temperature water bath.

4) Droplet Sampling and Size Analysis

As receiving surfaces of spray droplets for particle size analysis, various materials were selected both for amine and ester formulations for dry sampling or immersion sampling. Solid uncoated surfaces tested include KROMEKOTE paper, Whatman No. 40 filter paper, oil sensitive paper (spraying systems), and water sensitive paper (Wallace and Yoshida, 1980). Solid and coated surfaces tested include, kaolin layer on glass, cornstarch layer on KROMEKOTE paper, and film of smoke on glass from magnesium ribbon. Liquid surfaces, with variable immiscibility tested, include; mineral oil, baby oil, hydraulic oil, pneumatic lubricating oil, dioctylpathlate (or DOP), glyseline, (all petroleum based oils), castor oil and olive oil as vegetable oil. (Table 1).

A micro pipette (Eppendorf, model 4710) was used to disseminate droplets of 100-1000 microns diameter and to deposit on the selected surfaces. The black stains produced on white background were directly processed with an image analyzer (IBAS Interactive Image Analysis, Zeiss, West Germany) at the Department of Microbiology, University of Saskatchewan, to obtain particle size information.

5) Dye Tracer

The selection of tracer material for evaluation of droplet deposition

on target surfaces may be based on the following desirable characteristics; a) high sensitivity of detection possibly to 0.01 microgram, b) availability of rapid quantitative analysis, c) adequate solubility with carrier material and pesticide concentrate, d) distinctive fluorescent properties (primary exitation wave length) to differentiate from natural background, e) established fluorescene stabilities (hydrolysis and photolysis), f) moderate cost, and g) human and phytotoxicity (Yates and Akesson, 1963).

Dyes used are: Rhodamine B (Aldrich Chemical Co. Inc., Milwaukee, Wisc., catalogue No. R95-3) and Automate Red-B (Morton Thiokol Inc., Morton Chemical Division, Chicago, Il.). Both dyes have a distinctive red color which is advantageous in visual examination of a jump card without using a water-sensitive or oil-sensitive coating. For anticipated field trials of selected spray formulations in contained investigation (Phase II), Rhodamine B was selected for its known fluorescent properties in the previous investigation. (Maybank et al, 1978, McClure et al, 1968). For oil sprays, Automate Red-B has been commonly used for optical particle size analysis. (McClure, 1968).

The solubility of each dye was examined with the concentrate and with the carrier material. Depending on the concentration of dye in the total volume of spray liquid, a small amount of ethanol was first mixed with each dye before mixing with the concentrate.

4. Stationary Spray Test

1) Deposition Test

A spray liquid composed of 5% 2,4-D amine 80, 0.02% Rhodamine B

(fluorescent) dye, 25% emulsifier (CD-389 ATKEMIX), and 70% refined, degummed Canola oil (CSP Food) was prepared in a two litre quantity. The ratio of 2,4-D amine active ingredient (2.5%) to the fluorescent dye (RhB, 0.02%) was 125.

The prepared liquid was sprayed using a single conventional aircraft nozzle (D4-45) operated at 210-490 kPa (30-70 psi) of hydraulic pressure. It was necessary to use a higher pressure of 490 kPa (70 psi) to obtain sufficient break-up of the spray sheet in the laboratory test. A spray tank of 500 mL capacity was connected to a compressed air line and operated using a solenoid valve. Target surfaces (card) coated with magnesium oxide film were located at 1.0 m below the spray nozzle and one quick sweep of the card produced black stains on the white background. The image thus produced remained permanent.

2) Target Run-off Test

Plastic replicas of a weed plant (Lambs quarter) with a total surface area of 22 cm^2 were made of polyethylene by injection moulding. The material thus lends itself to spray samplings as no background is generated when washed in ethanol. A total of 15 replicas were exposed to the spray either in single or in pairs by passing them under the center of the spray cone of the spray nozzle. After exposure, they were extracted with 100 mL of ethanol into 250 mL wide mouth jars.

The effect of rain washing the 2,4-D amine off the plastic leaves was investigated. When using an aqueous mixture of 2,4-D amine, the effect of a heavy rain shortly after application can be devastating. Fifteen more replicas were exposed in groups of three to various durations

of a 55-60 mm/hr rain in a rain simulator chamber. This is equivalent to a 2.25 inch rain in one hour, something experienced in a heavy thundershower. Exposure periods were 1.5, 3, 5, 8 and 30 minutes. After exposure to the rain, samples were extracted in the same way.

III. RESULTS AND DISCUSSION

1. Physical Properties

1) Compatibility

a) Ester Formulation

Dissolution of two liquids was observed when 2,4-D ester LV 112 was mixed with raw degummed Canola oil at 3.6:95 and 10:90 volume ratio (samples No. 1.5) and with refined Canola oil at 10:90 ratio (samples No. 30,31). Dissolution of two liquids was also achieved when 2,4-D ester LV 112 was mixed with raw or refined Canola oil and emulsifiers. Cases observed were: CANPLUS at mixing ratios of 5:90:6 where first figure is 2,4-D%, second is Canola %, third is emulsifier (sample No. 10), 5:80:15 (sample No. 18), 5:85:10 (samples No. 18), 5:85:10 (samples No. 32, 33) at 10:85:5 (sample No. 32), ATSURF at mixing ratio of 5:80:15 (sample No. 20) and 5:90:5 (sample No. 22). (Table 2, Appendix).

b) Amine Formulations

The solutions which demonstrated miscibility after agitation for at least several hours were: No. 4 (5:95:50 mg ATMUL 124), No. 6 (5:70:150 mg ATMUL 124, Ethanol 12 ml, Butanol 15 ml) which formed an emulsion, No. 7 (5:82:150 mg ATMUL 124, Ethanol 5 mil, Butanol 8 mil) formed an emulsion The emulsions were not stable for periods longer than several hours, without agitation. Sample No. 14 (5:60:17 ml Ethanol, 20 ml Butanol, 6 ml Linoleic acid, 3 ml Triethylamine) a microemulsion was formed but some precipitate was found on the bottom of the container, the solution is stable. No. 23 (5:70: 25 ml CD-289) solution was miscible and stable for up to a day.

Mixture No. 24 (5:80:20 ml CD-389) did not have enough emulsifier to keep the 2,4-D amine in solution for the same period of time as mixture

No. 23. All the other mixtures tried were not miscible or separated after agitation almost immediately. (Table 2, Appendix).

2) Viscosity and Surface Tension

The temperature dependency in the kinematic viscosity of canola oil was studied elsewhere. Assuming that the air temperature at the time of mid-day spraying of herbicide in June-July is about 30 degrees C and early morning is 10 degrees C, the viscosity values rose from 50 to 100 centistokes. (Figure 1). However, when 2,4-D ester or amine were mixed with adjuvants, the liquid became generally more viscous. The rate of increase was greatly affected in the lower temperature range (10-20°C). Amine formulation of 2,4-D with Canola oil tended to be more viscous than the ester counterpart. The viscosity of the mixed spray liquid was proportional to the mixing rate of adjuvant (CANPLUS). The values of kinematic viscosity for the applicable range of mixing rate, however, remained 65 to 80 centistokes (Figure 2). The only precaution required for spraying Canola oil-based spray may be, therefore, the time of application when the air temperature is lower than 20 degrees C.

The values of surface tension of 2,4-D ester with Canola oil converged to 36 dynes/cm after the mixing rate of adjuvant exceeded 5%. (Figure 3) The value for conventional water base spray of ester is 32.5 dynes/cm (Yoshida and Maybank, 1969). (Figure 4). Surface tension of canola oil alone was at 32.5 dynes/cm level, however, adding adjuvant increased the values of surface tension indicating that the spreading ability of canola oil-based spray may not be compatible to water-based spray with appreciable reduction of surface tension by mixing the concentrate (Yoshida and Maybank, 1969).

3) Stability of Spray Liquid

a) Esters

Although the esters do dissolve Canola there appears to be some settling out over 3-5 days in the ester solution. This also occurs at low emulsifier concentrations e.g. 6 and 10% CANPLUS 129 and 6% ATSURF 205. It is not visible when the emulsifer concentration is brought up to 15% for CANPLUS 129 and ATSURF 205, the latter two formulations at 15% are recommended for use with the ester. (Appendix).

b) Amine

The difficulty of forcing a water souble mixture into a vegetable oil is paramount here. The amine mixture is worthy of investigation due to it's much reduced volatility from that of the ester for spray applications.

In order to keep the amine mixture in solution it was necessary to use a high emulsifier concentration (25% of CD-389). It is important to have sufficient agitation in the tank of the aircraft for complete mixing in any oil mixture. The agitation is a more critical factor in spraying oil as a carrier than in water.

The chemical make up of Canola oil occurs from the condensation of glycerol and fatty acids predominately oleic 55% (C18 one double bond), linoleic 26% (C18 two double bonds), and linolenic 10% (C18 three double bonds). These three acids account for 91% of the fatty acid content of Canola, (Stevenson et al, 1981) (Appendix).

The biological efficacy of 2,4-D mixtures using Canola oil as a carrier have not been investigated fully as yet.

Very preliminary work has been done using Canola both as an adjuvant

with water and as a carrier. Preliminary data show variability when different herbicides are used, 2,4-D ester was found to have better efficacy when Canola oil was used as a carrier rather than an adjuvant with water, but overall efficacy was slightly worse with oil as a carrier. It must be stressed that these results are very preliminary and further work will be done in the coming year (Ashford, 1984).

4) Spray Collection Media

In order to determine the size of droplets impinging on a receptor surface, the spreading of 2,4-D in Canola oil carrier was examined on various surface materials. Solid receptor surfaces were with or without coating and liquid receptor surfaces were prepared in a thickness greater than the expected maximum diameter of spray droplets. For solid surfaces, stains produced were visually examined for sharpness of stain edge, contrast of stain, and stability of stains created. For liquid receptor suspended droplets were examined for immiscibility with target liquid, contrast of dyed droplets, spreading and stability after deposition. (Table 1). After examining 20 different receptors, a surface of black art paper with a coating of magnesium oxide was selected as the best surface for Canola oil-based 2,4-D spray. The card produced clear-edged black stains on a white background.

The spread factors determined for most adequate formulations prior to deposition tests were 3.0 for 2,4-D ester with canola oil and 2.7 for 2,4-D amine with Canola oil as the carrier. (Figures 5 and 6).

2. Characteristics of Droplet Dissemination

1) Droplet Size Spectra

The values of the volume median diameter decreased with the increasing hydraulic pressure. 2,4-D ester applied with a D-4-45 hollow cone nozzle produced droplets of various si.es from 500 μm to 1050 μm aerodynamic diameter in 2,4-D ester formulation and 670 to 1350 μm in amine formulation. These size ranges may not be adequate for weed control by phenoxy herbicide. Coarse droplets were produced mainly due to the increased value of surface tension and viscosity that consequently made break-up into spray more difficult (Figures 7 and 8).

The optimal size of droplets for weed control efficacy is discussed elsewhere, however, the range may be between 100 and 250 μm. The droplet size obtained in this study still seems to be coarse. The use of increased hydraulic pressure (above 500 kpa) and of spray nozzles with smaller orifice size will produce smaller droplets.

2) Deposition Density and Size Uniformity

The deposition density of spray volume on a target (jump cards) is expected to increase with the hydraulic pressure, because the discharge rate of nozzle is proportional to the hydraulic pressure. However, due to the difference of physical properties between amine and ester formulations, the amine spray required higher pressure (400 Kpa) to produce a nominal deposition density of 50 mg/m^2 while the ester formulation required 300 Pka (Table 3, Figure 9).

The uniformity of droplet size on a deposition target is expressed by Sigma-G which is the ratio of 84% cumulative droplet size (D84) to the volume median diameter (D_{50}). A value of Sigma-G at unity means the distribution is perfectly uniform. The values were 1.48 for amine and 2.1 for ester formulations. This indicates that the amine formulation

produced more uniform droplet sizes in the spray compared to ester formulation, while amine sprays were producing coarser droplets (VMD-700 ∿ 1390 μm) than ester spray (VMD = 440 ∿ 1100 μm). The value of Sigma-G might affect the efficacy of weed control.

3) Droplet Retention on Target Surface

The mass of active ingredient (2,4-D AE) retained on the surface of the target plants (plastic weeds) was correlated with the duration of rain. After nine minutes of exposure 94% of mass was retained whereas 87% was retained after 30 minutes of exposure (Figure 10). The coefficient of variation (CV) of the deposition on the plastic weeds was at the 20-24% level. In comparison to the CV of 40-46% obtained for aerial spray using water as a carrier under typical field conditions, the laboratory tests showed much lower values using Canola oil as carrier. This difference may be due to shear forces on the spray break-ups usually encountered under typical field conditions.

3. Recommendation of Relevant Mixing Ratio

The best recommended mixing rates of 2,4-D concentrate, canola oil and emulsifier were selected:

Name of Adjuvant	2,4-D Formulation (mL)	Canola Oil (mL)	Adjuvant (ml)
ATMUL, I124	Amine 5	95	50 mg
CD-389	Amine 5	70	25
CANPLUS I24	Ester 5	80	15
ATSURF 205	Ester 5	80	15

IV CONCLUSIONS

1. The 2,4-D ester formulation dissolved in Canola oil, the amine formulation developed miscibility only with the help of adjuvant and agitation.
2. Canola oil-based sprays with adjuvant resulted in increased viscosity which is remarkably sensitive to the temperature.
3. The surface tension of Canola oil-based sprays increased with adjuvant concentration.
4. Amine formulation with Canola oil required a high percentage of adjuvant for prolonged liquid stability.
5. Black art paper coated with magnesium oxide film was found an efficient collection medium.
6. Droplets of Canola oil-based low-volume spray tended to be coarser than its counterpart water-based spray from laboratory tests.
7. Superior uniformity of droplet size distribution was obtained with the amine spray compared to the ester counterpart from laboratory tests.
8. The retention rate of Canola oil-based spray on plastic replicas of weeds was up to 94% after exposure to a rain shower.
9. Four commercial adjuvants tested were found to be effective in developing required properties of Canola oil-based spray for low-volume aerial application.
10. The most effective rates of adjuvant mixing for Canola oil-based spray of 2,4-D were proposed.

V. ACKNOWLEDGEMENTS

This study was conducted as a part of Agriculture Canada's Agricultural Engineering Research and Development (AERD) program, contract serial number 0 SG84-00006. The scientific authority of this contract research is Dr. R.J. Ford, Agriclutre Canada Research Station, Saskatoon. During the course of investigation, various forms of cooperation and consultation were provided by; James Ross, R. Begrand, Mr. J. Hudson, Mr. B. Zuk of SRC and Mr. R. Secor (P.A. Pulp) and Mr. A.W. Nicholls of Atkemic Inc. in providing commercial surfactant aspects and consultation, Professor W.E. Yates, University of California, Davis, visiting scientist at the Saskatchewan Research Council investigating spray dissemination aspects, professor W.B. Reed of Agricultural Engineering in providing his laboratory facility for spray tests, and Mr. D. Klippenstein of Department of Applied Microbiology in analyzing particle size. The authors express their appreciation to each individual.

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Table 1. Characteristics of Spray Collection Media

1. Solid Receptor

Target Surface	Surface Coating	Dye	2,4-D	Stain Characteristics		
				edge	Contrast	Others
Kromekote paper	No	RhB	Amine	Fuzzy	colour separation	Long time to dry
Kromekote paper	cornstarch	RhB	Amine	Fuzzy	colour separation	
Kromekote paper	chalk powder	RhB	Amine	Less fuzzy	no colour separation	
Filter paper, Whatman 40	cornstarch	RhB	Amine Ester	Fuzzy	Moderate poor	
Oil sensitive paper	No	RhB	Amine	Fuzzy	Black colouring	
Water sensitive paper	No	RhB	Amine	Fuzzy	Colour separation	Long time to dry
Black Art paper	MgO	RhB	Amine	Clear	Black	Stable

2. Liquid Receptor

Target Surface	Dye	2,4-D	Droplet Characteristics			
			Immiscibility	Contrast	Spread	Stability (5 min)
DOP	RhB	Amine	No	poor	-	-
Glyselin	RhB	Amine	No	poor	-	-
Mineral oil	RhB	Amine	-	clear edge	evenly	stable
Mineral oil	RhB	Ester	-	weak	-	-
Nojol	RhB	Amine	Yes	clear edge	evenly	stable
Nojol	RhB	Ester	-	weak	-	-
Caster oil	Automate	Amine	No	dissappear	evenly	unstable
Baby oil	RhB	Amine	Yes		at bottom	unstable
Baby oil	RhB	Ester	-	poor	-	unstable
Olive oil	RhB	Ester	No	poor	partially	unstable
Water	RhB	Amine	No	-	instantly	-
Hydraulic Fluid	RhB	Amine	Yes	clear edge	at bottom	stable
Pneumatic oil	RhB	Amine	Yes	clear edge	at bottom	stable

Table 2. Summary of Spray liquid characteristics

Sample No.	2,4-D Formulation	Canola oil	Additives	Liquid Characteristics
1	Ester LV 112 3.6 mL	Raw Degummed 95 mL	stirring for 2 minutes	Dissolved, after standing no separation.
2	Amine 80 5 mL	Raw Degummed 95 mL	ATMUL 124 (HLB 2-3) 100 mg	Amine sinks to bottom separation after overnight
3	Amine 80 5 mL	Raw Degummed 75 mL	ATMUL 124 (HLB 2-3) 250 mg, stirred 20 min.	Appeared to separate overnight, resuspends on agitation.
4	Amine 80 5 mL	Raw Degummed 95 mL	ATMUL 124 (HLB 2-3) 50 mg, stirred 20 min.	Appeared to be best for emulsifing the amine. Heating help dissolution.
5	Ester LV 112 10 mL	Raw Degummed 90 mL	No additive	Dissolution on stirring immediately, after several days some falling out of Ester
6	Amine 80 5 mL	Raw Degummed 70 mL	ATMUL 150 mg, Ethanol 12 mL, Butanol 15 mL, stirred and heated for 45 minutes	Formed emulsion.

Table 2. Summary of Spray liquid characteristics (continued)

Sample No.	2,4-D Formulation	Canola oil	Additives	Liquid Characteristics
7	Amine 80 5 mL	Raw Degummed 82 mL	ATMUL, 150 mg, Ethanol 5 mL, Butanol 8 mL, stirred and heated for 45 minutes.	Formed emulsion
8	Amine 700 5 g	Raw Degummed 94 g	ATMUL 124, 100 g. Added to oil, heat and stir 10 minutes	Too much emulsifier does not dissolve.
9	Amine 700 10 g	Raw Degummed 90 mL	ATMUL 124, 250 gr, added to oil then 2,4-D.	Did not dissolve.
10	Ester LV 112 5 mL	Raw Degummed 90 mL	CANPLUS 129, 6mL	Dissolved
11	Amine 700 2.5 mL	Raw Degummed 45 mL	CANPLUS 3.0 mL, ATMUL I24, 100 mg	Did not dissolve.
12	Amine 80 5 mL	Raw Degummed 95 mL	Calcium salt of Ivory Soap 100 mg	Did not dissolve Amine at all.
13	Amine 80 5 mL	Refined	Calcium salt soap, 52 mg	Did not dissolve Amine at all.

Table 2. Summary of Spray liquid characteristics (continued)

Sample No.	2,4-D Formulation	Canola oil	Additives	Liquid Characteristics
14	Amine 80 5 mL	Refined, 60 mL	95% Ethanol 17 mL, Butanol 20 mL, Linoleic acid 6 mL, Triethylamine 3 mL.	Formed micro emulsion. Black material formed on bottom of jar.
15	Amine 80 5 mL	Refined, 95 mL	2 drops of Tween 60 Blend and heated	Very slight if any dissolution.
16	Amine 80 5 mL	Refined 95 mL	4 drops of Tween 60 ATMUL 124, 25 mg Heated and mixed	Partially Dissolves with agitation but settles out.
17	Amine 80 5 mL	Refined, 80 mL	CANPLUS 129, 15 mL	Separates on standing over several hours. Stable if agitated.
18	Ester LV 112 5.0 mL	Refined, 80 mL	CANPLUS 129, 15 mL	Dissolves totally. Stable
19	Amine 80 5.0 mL	Refined, 80 mL	ATSURF 205, 15 mL	Separates on standing, misible if shaken.
20	Ester LV 112 5.0 mL	Refined 80 mL	ATSURF 205, 15 mL	Dissolves ester (stable).

Table 2. Summary of Spray liquid characteristics (continued)

Sample No.	2,4-D Formulation	Canola oil	Additives	Liquid Characteristics
21	Amine 80 5.0 mL	Refined, 89 mL	ATSURF 205, 6 mL	Separates on standing doesn't totally dissolve amine.
22	Ester LV 112 5.0 mL	Refined, 89 mL	ATSURF 205, 6 mL	Settles out on standing
23	Amine 80 5 mL	Raw Degummed, 80 mL	CD-289, 15 mL	Did not fully dissolve amine, separates on standing overnight.
24	Amine 80 5.0 mL	Raw Degummed, 70 mL	CD-389, 25 mL	Did not separate on standing, fully mixed, separates on standing several days.
25	Amine 80 5.0 mL	Raw Degummed, 75 mL	ALSUL, 20 mL	Separated on standing overnight. Ammonium lignosulphate did not fully mix in canola.
26	Amine 80 5.0 mL	Raw Degummed, 70 mL	CANPLUS 129, 25 mL	Separated on standing overnight, works well when agitated.
27	Amine 80 5.0 mL	Raw Degummed, 70 mL	ALSUL, 10 mL CANPLUS 129, 15 mL	Some separation overnight. Solution on agitation. Best mix for ALSUL

Table 2. Summary of Spray liquid characteristics (continued)

Sample No.	2,4-D Formulation	Canola oil	Additives	Liquid Characteristics
28	Amine 80 5.0 mL	Raw Degummed, 70 mL	CD-389, 10 mL ALSUL, 10 mL	separation overnight. ALSUL does not fully dissolve with CD-389.
29	Ester LV 112 10 mL	Refined, 84 mL	CANPLUS, 6 mL	Totally dissolved over night.
30	Ester LV 112 10 mL	Refined, 90 mL	No additive.	Totally dissolved.
31	Ester LV 112 10 mL	Refined, 90 mL	No additive.	Totally dissolved.
32	Ester LV 112 5 mL	Refined, 89 mL	CANPLUS, 6 mL	Totally dissolved overnight.
33	Ester LV 112 5 mL	Refined, 85 mL	CANPLUS, 10 mL	Totally dissolved overnight.

Note: ALSUL represents ammonium lignosulphonate
CD-389
CANPLUS 129
ATSURF 205
ATMUL 124
TWEEN 60
are all trade names of emulsifiers from Atkemix Inc.

Table 3. Uniformity of Particle Size Distribution

Ester

Hydraulic Pres. (Kpa)	210	210	280	350	350	420	420	420	490
VMD (μm)	1020	1100	1000	960	760	770	500	650	640
D84 (μm)	2050	2050	2300	1600	1300	1500	750	1400	1400
Sigma-G	2.00	1.86	2.3	1.67	1.71	1.95	1.5	2.15	2.19
Mean	2.05		2.3	1.69			1.87		1.93

Amine

490	Mean	210	280	280	350	420	490	490	Mean
440	(n=10)	1370	1120	1160	940	660	660	700	(n=7)
730		2050	1900	1600	1400	840	1000	1100	
1.66	2.1	1.5	1.7	1.38	1.49	1.23	1.52	1.57	1.48
		1.5	1.54		1.49	1.27	1.55		

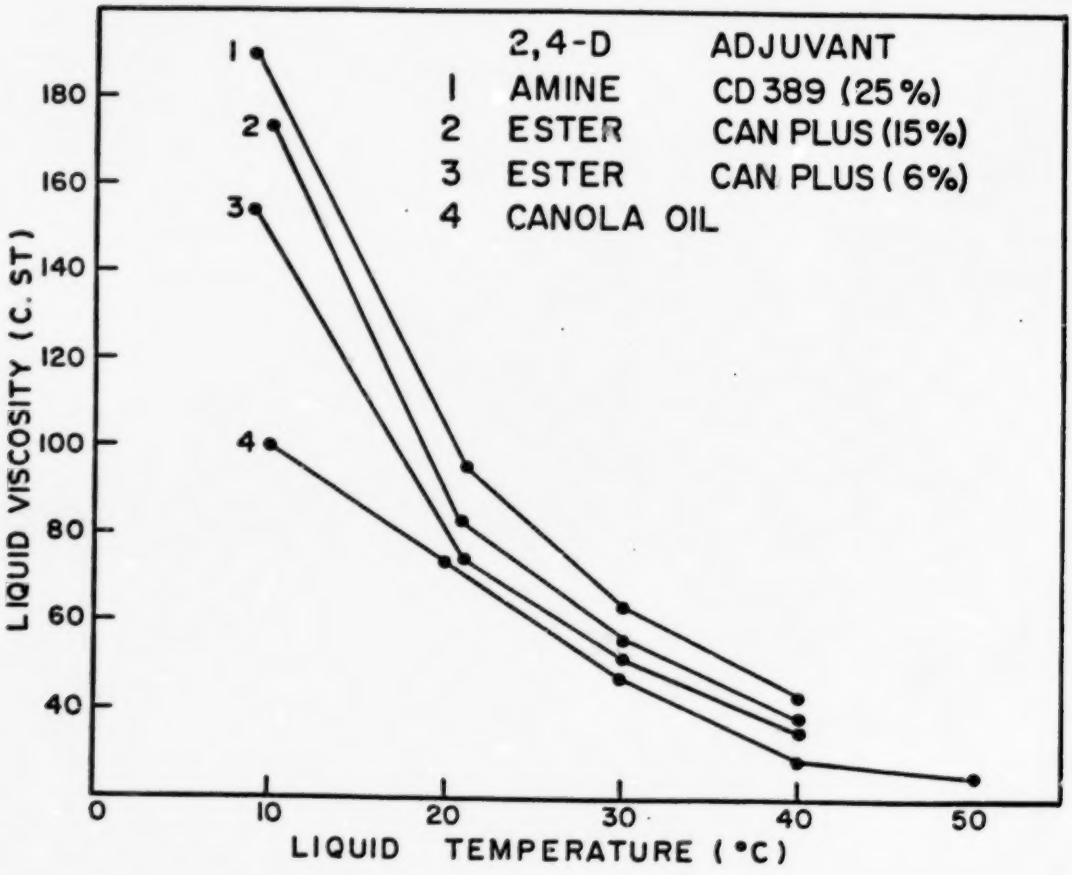


Figure 1. Viscosity of spray liquids of various composition affected by liquid temperature.

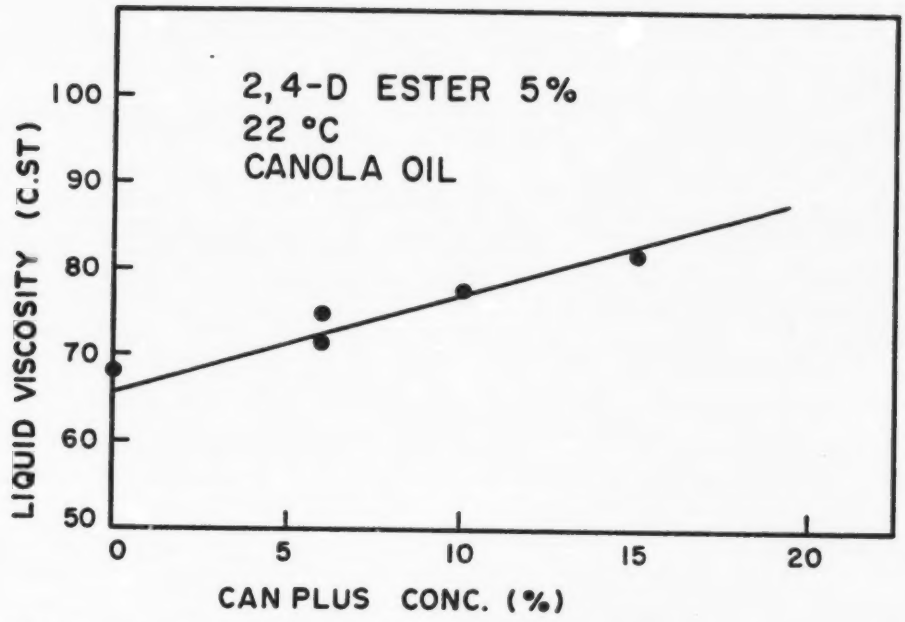


Figure 2. Effect of adjuvant concentration on the viscosity of spray liquid (Canola oil).

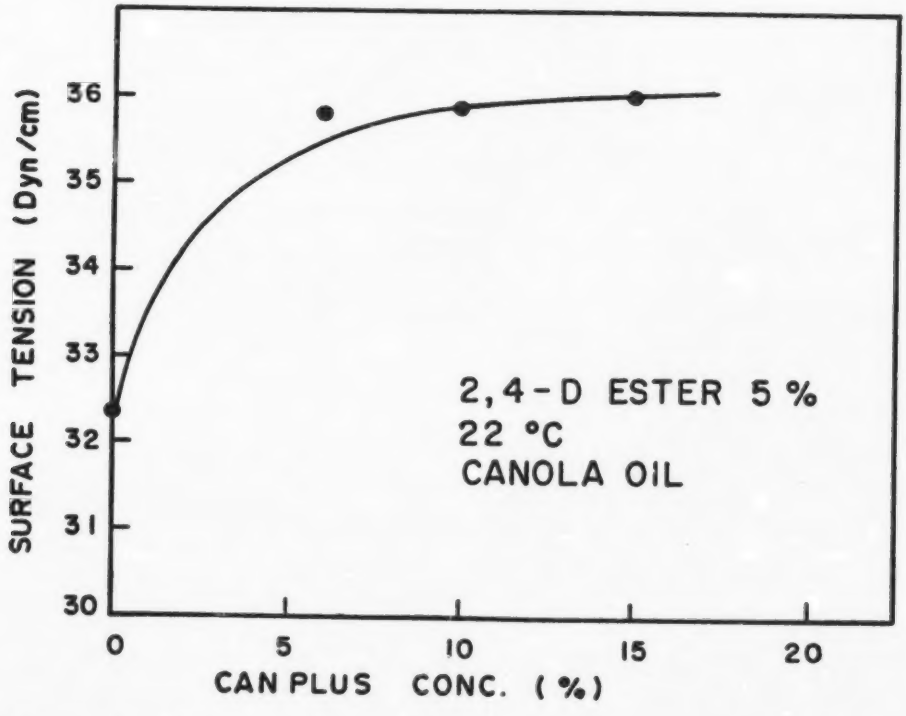


Figure 3. Effect of adjuvant concentration on the surface tension of spray liquid (Canola oil).

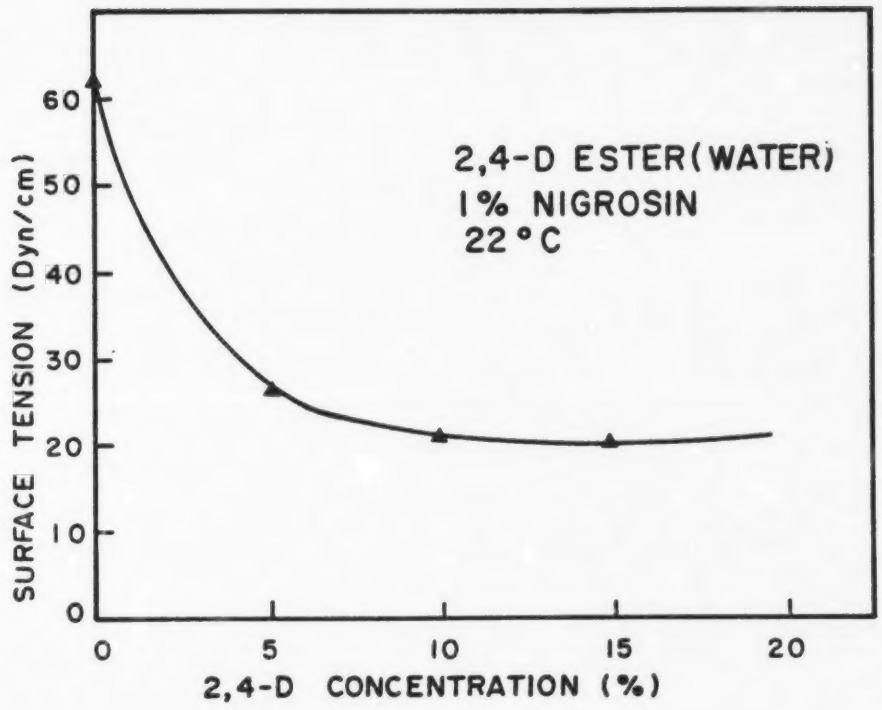


Figure 4. Effect of 2,4-D concentration on the surface tension of spray liquid (water).

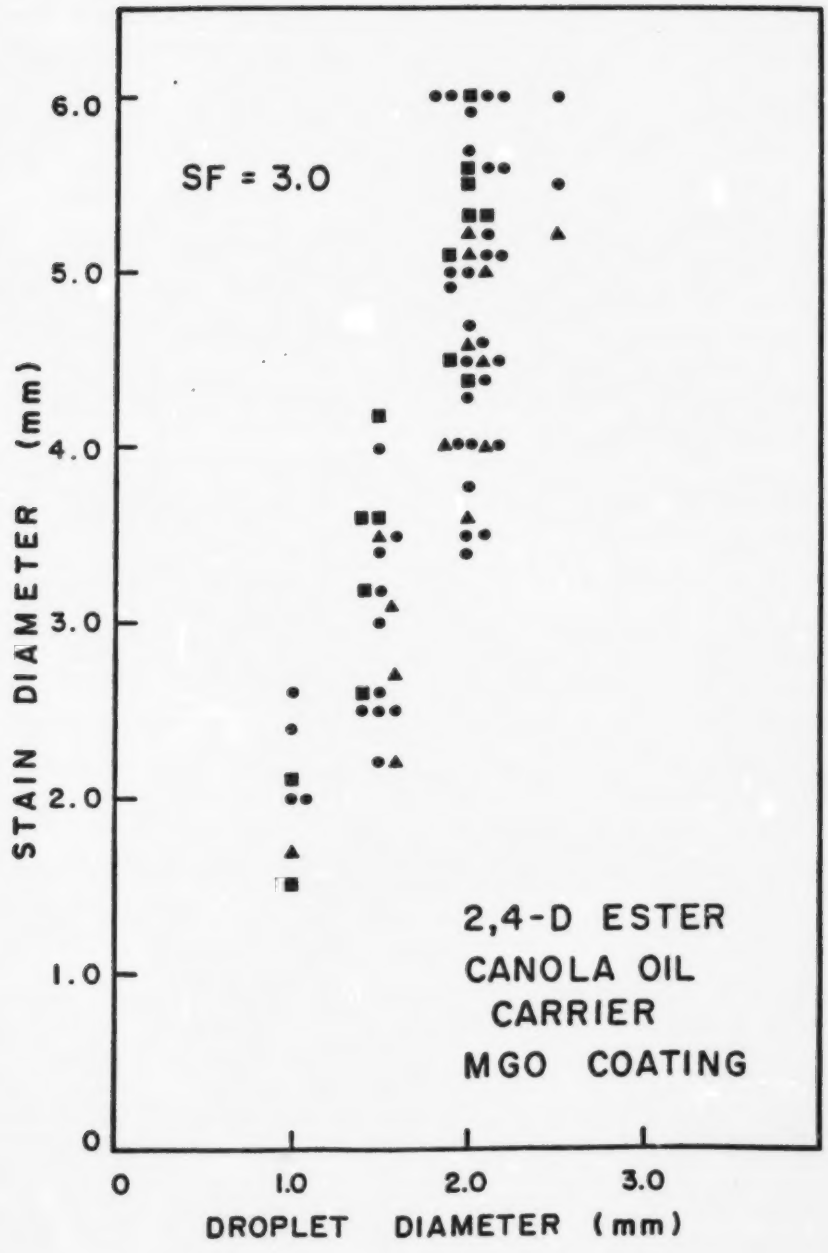


Figure 5. Spread factor determination of 2,4-D ester spray liquid with canola oil.

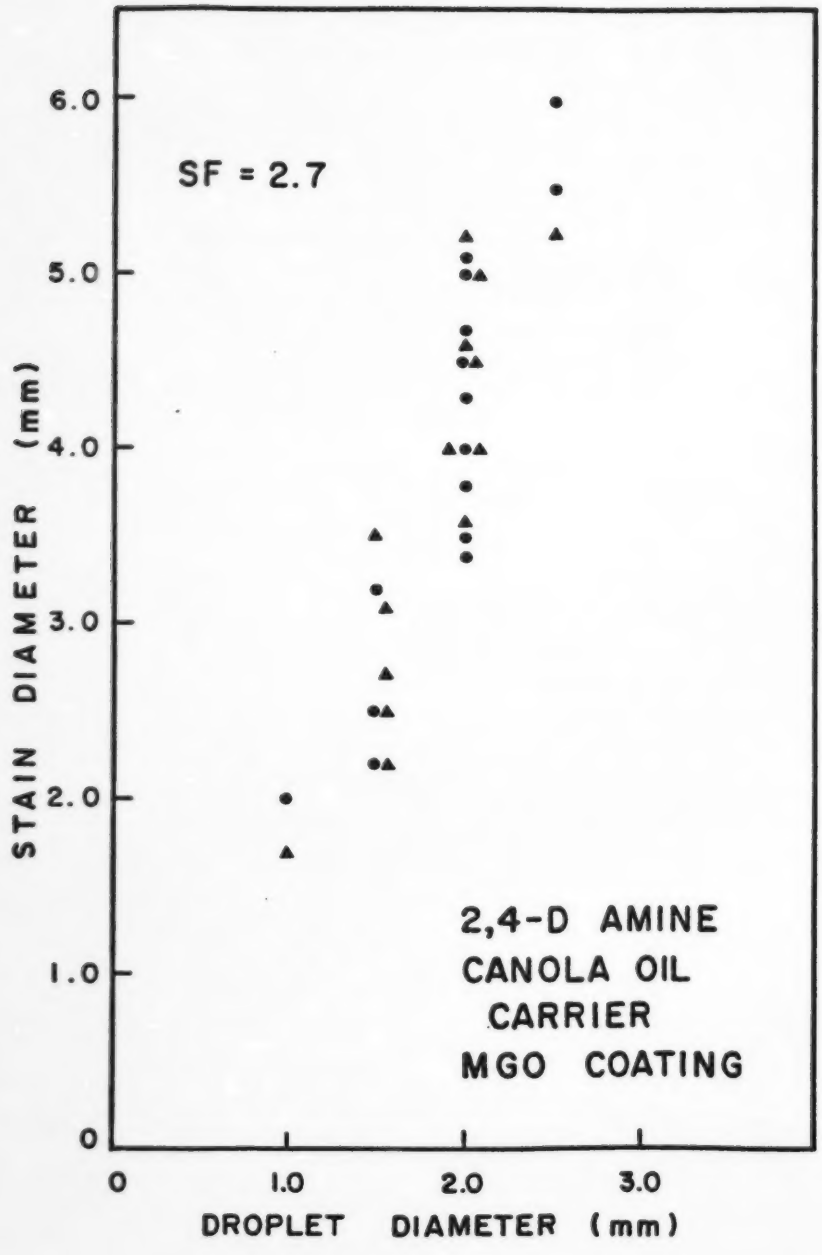


Figure 6. Spread factor determination of 2,4-D amine spray liquid with canola oil.

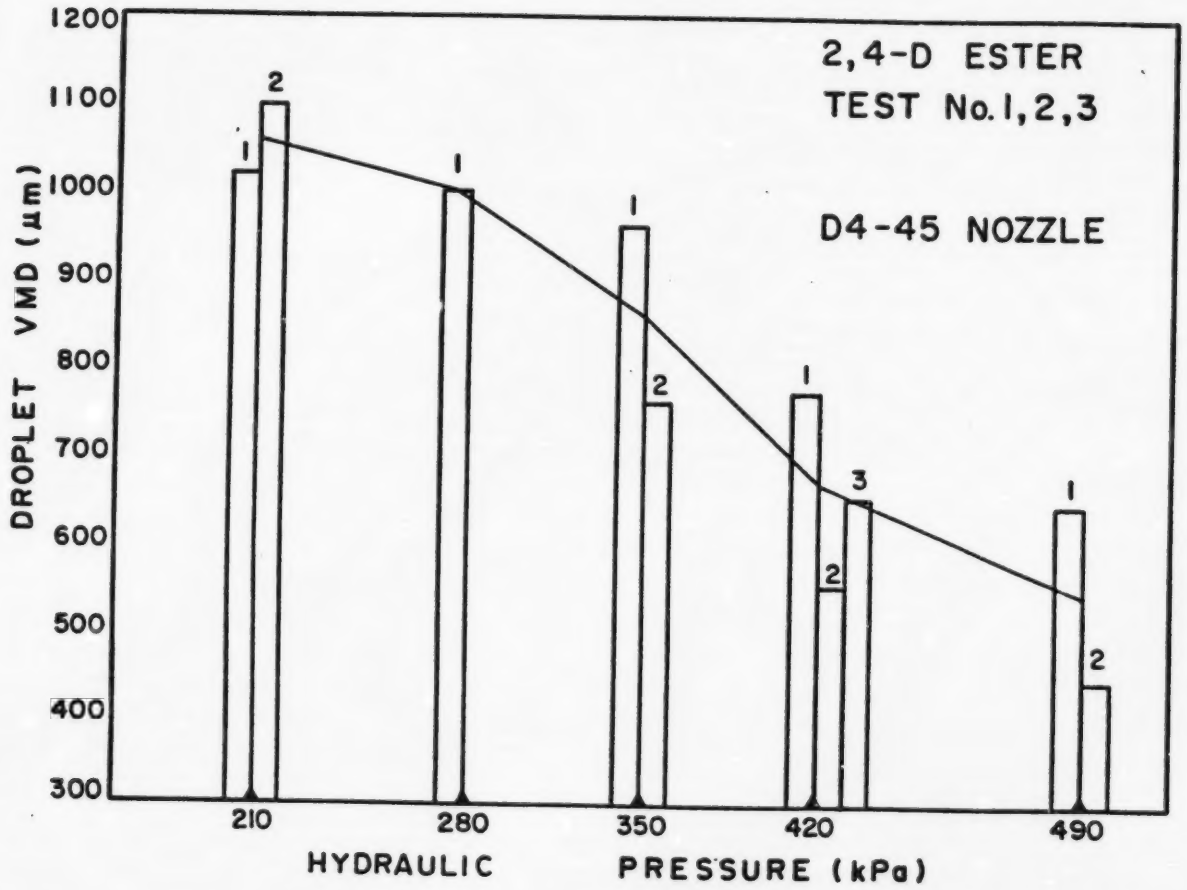


Figure 7. Effect of hydraulic pressure on the volume median diameter of spray droplets produced in 2,4-D ester.

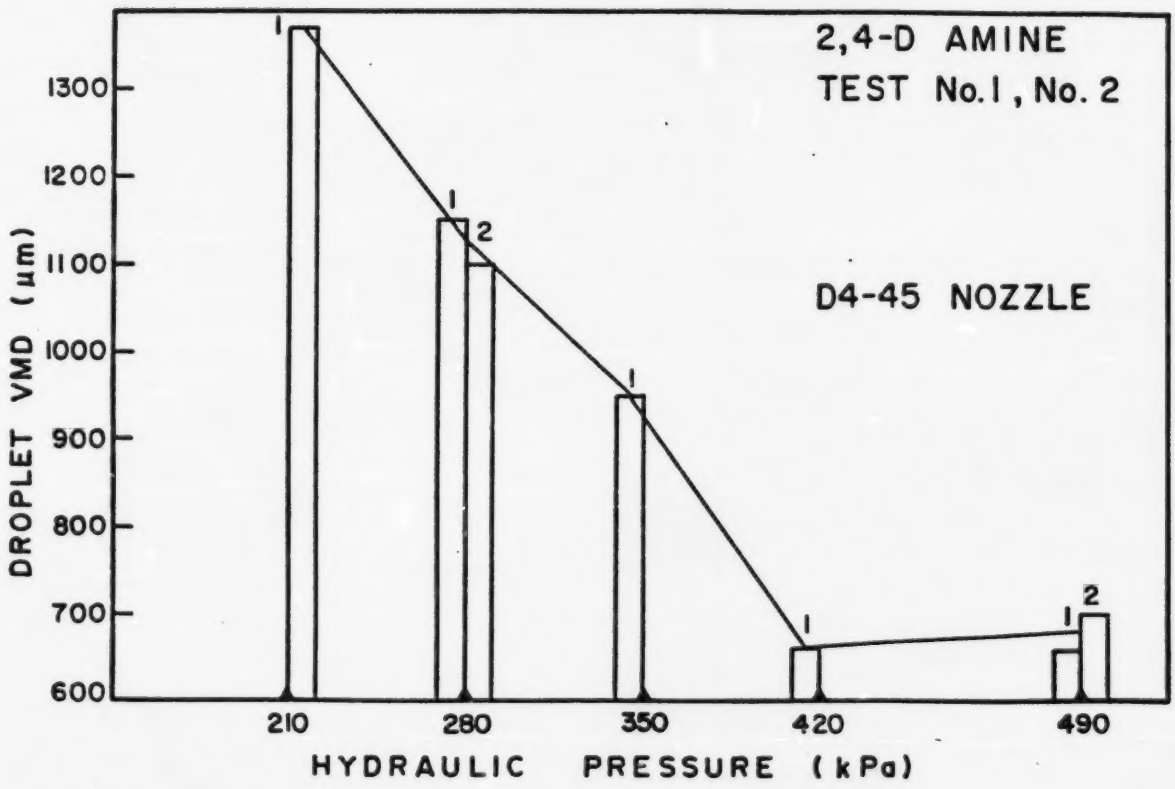


Figure 8. Effect of hydraulic pressure on the volume median diameter of spray droplets produced in 2,4-D amine.

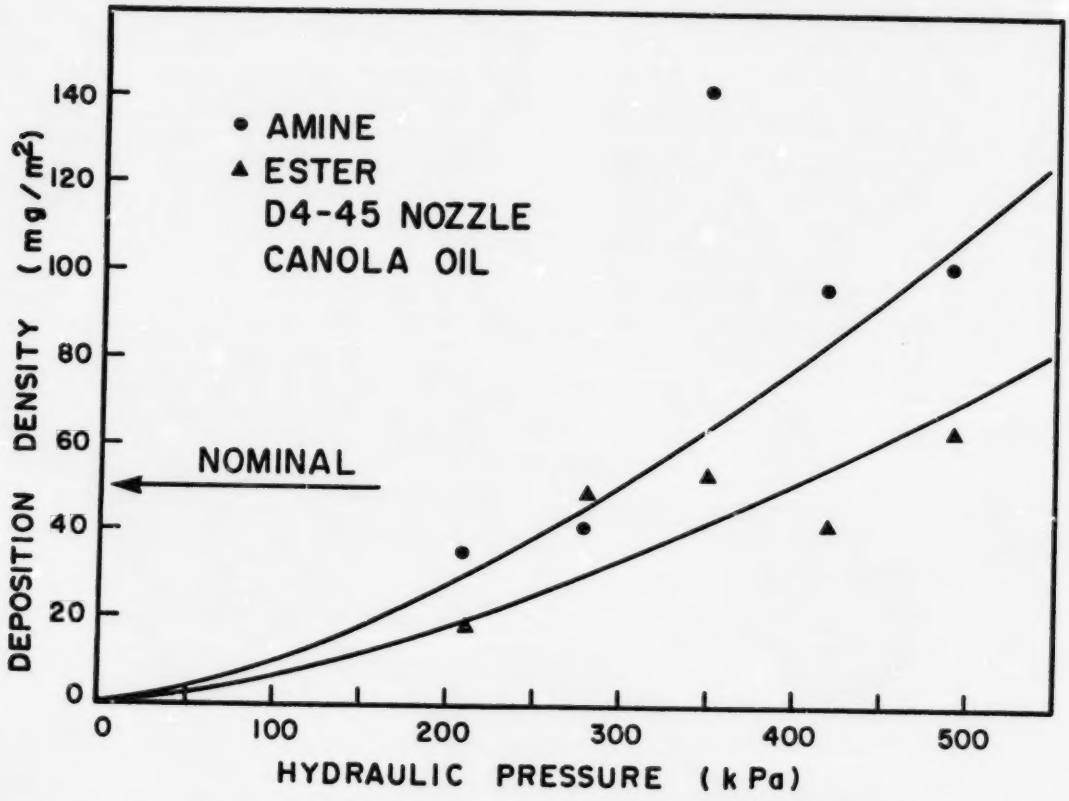


Figure 9. Deposition density of spray liquid (Canola oil) affected by hydraulic pressure.

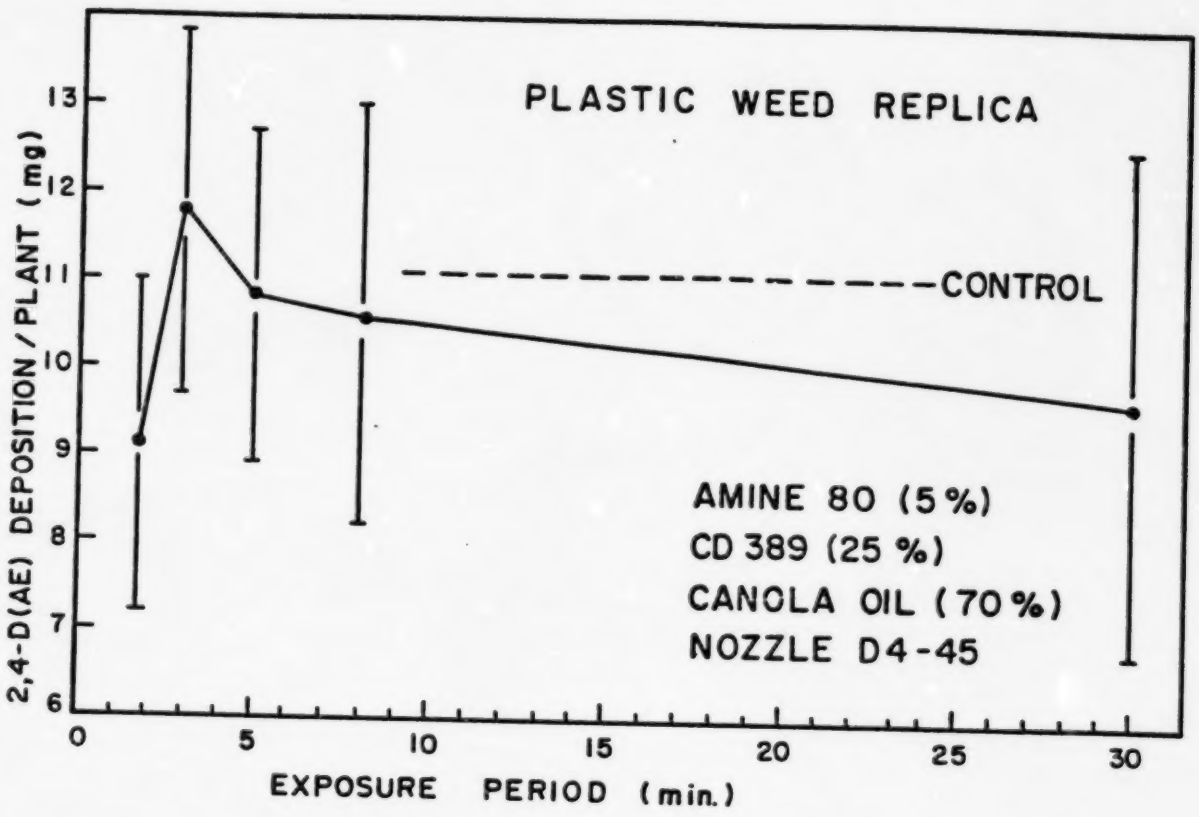
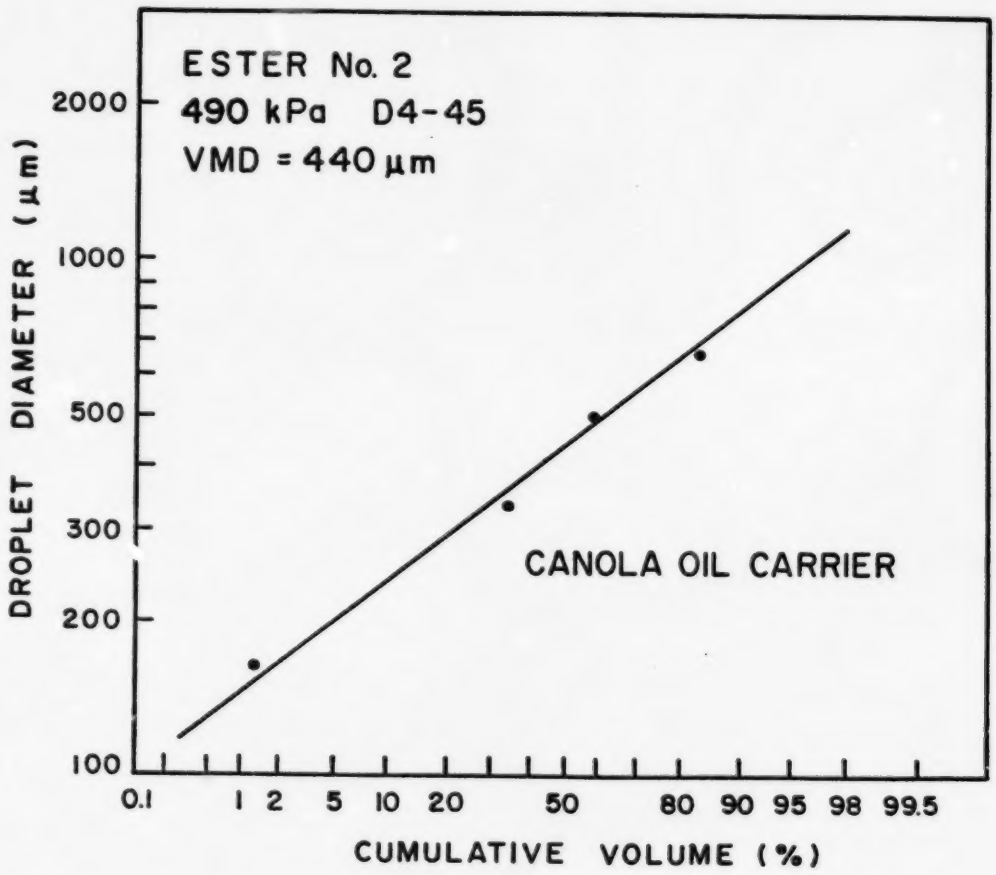
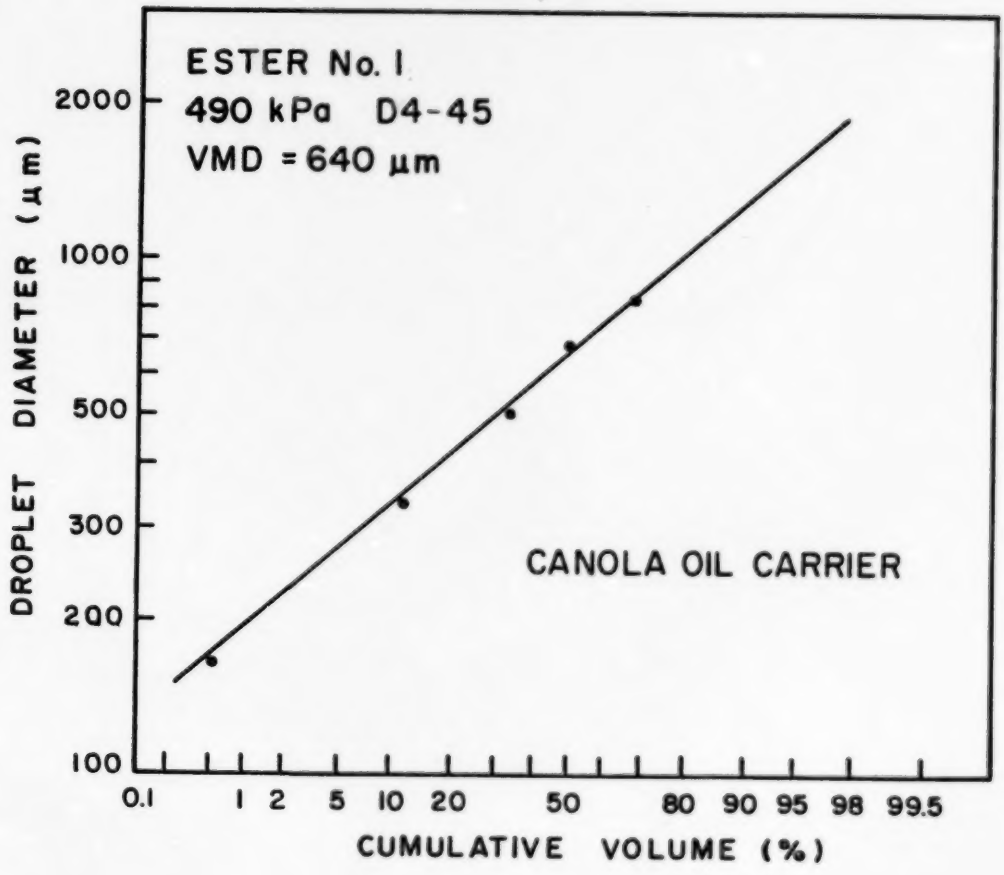


Figure 10. Retention of canola oil spray on plastic weed.

APPENDIX


ESTER No. 2
490 kPa D4-45
VMD = 440 µm
CANOLA OIL CARRIER
DROPLET DIAMETER (µm)
2000
1000
500
300
200
100
0.1
1
2
5
10
20
50
80
90
95
98
99.5
CUMULATIVE VOLUME (%)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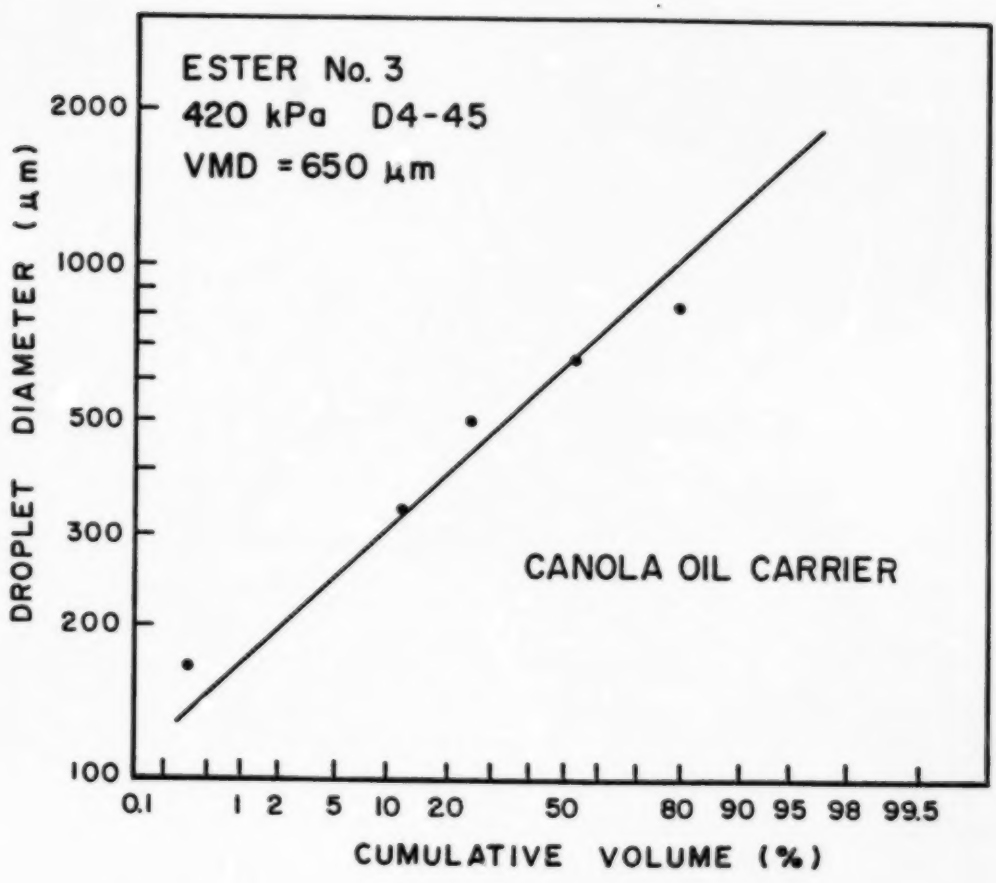
VMD = 640 µm
CANOLA OIL CARRIER
DROPLET DIAMETER (µm)
2000
1000
500
300
200
100
0.1
1
2
5
10
20
50
80
90
95
98
99.5
CUMULATIVE VOLUME (%)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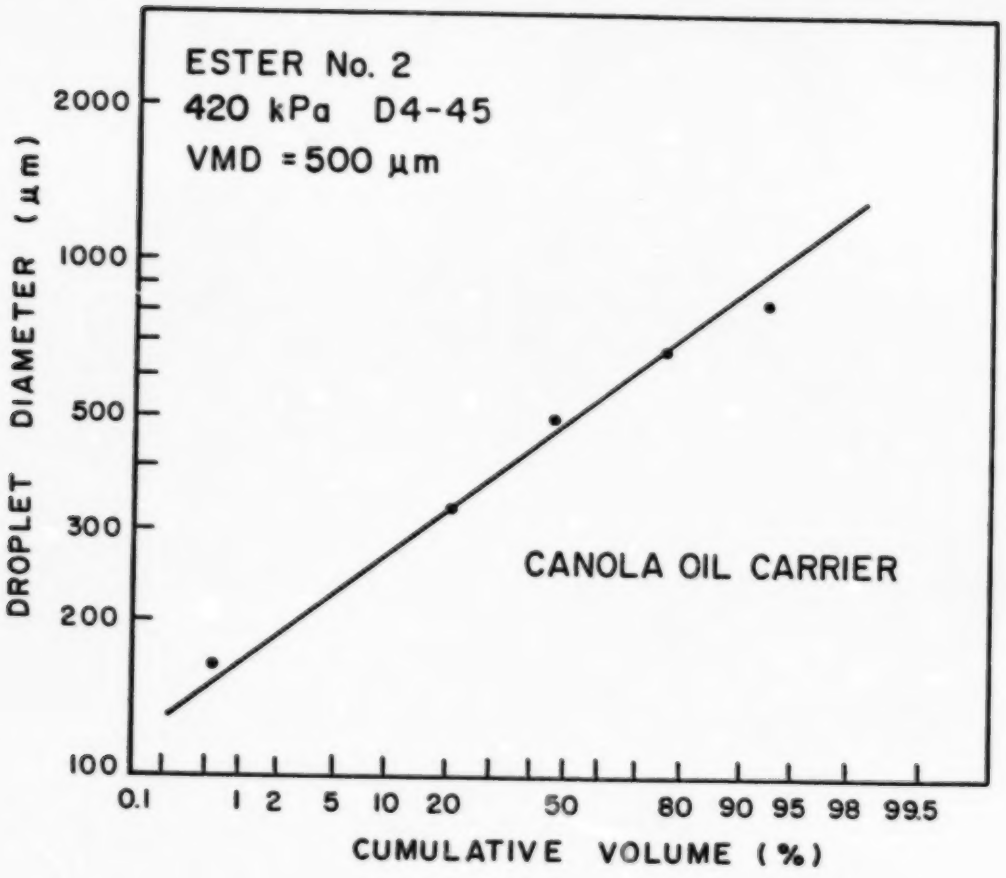
VMD = 650 µm
CANOLA OIL CARRIER
DROPLET DIAMETER (µm)
2000
1000
500
300
200
100
0.1
1
2
5
10
20
50
80
90
95
98
99.5
CUMULATIVE VOLUME (%)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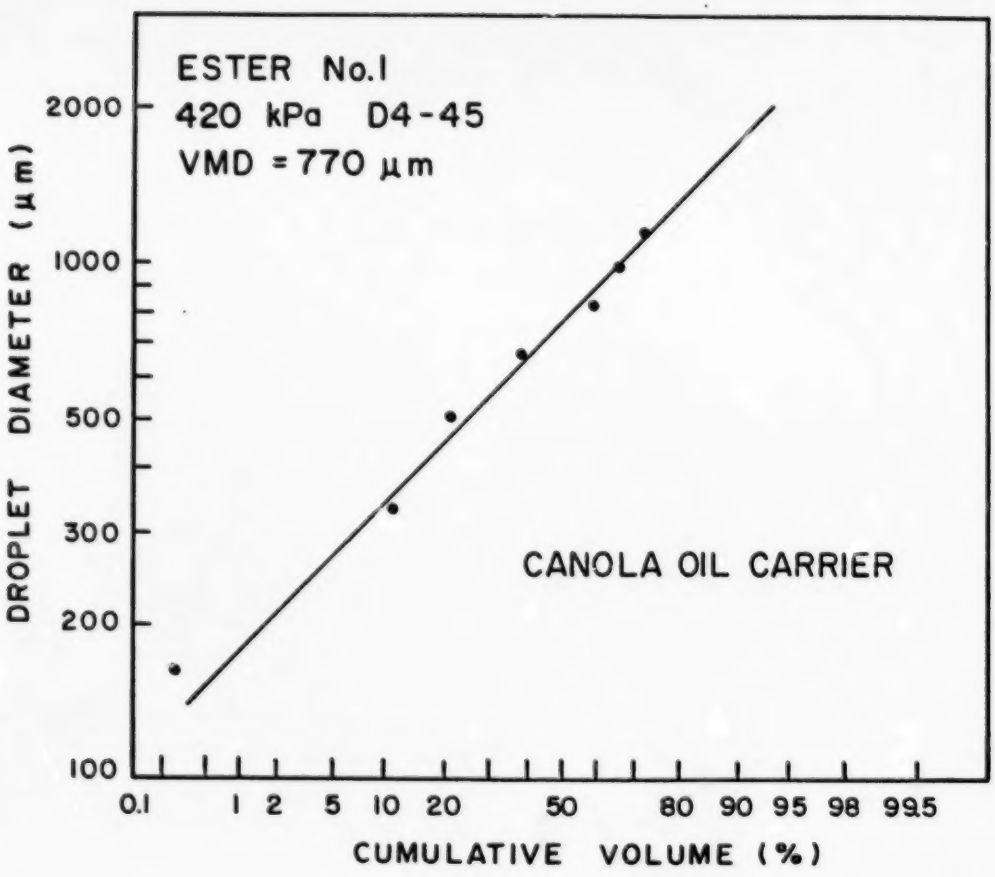
VMD = 500 µm
CANOLA OIL CARRIER
DROPLET DIAMETER (µm)
2000
1000
500
300
200
100
0.1
1
2
5
10
20
50
80
90
95
98
99.5
CUMULATIVE VOLUME (%)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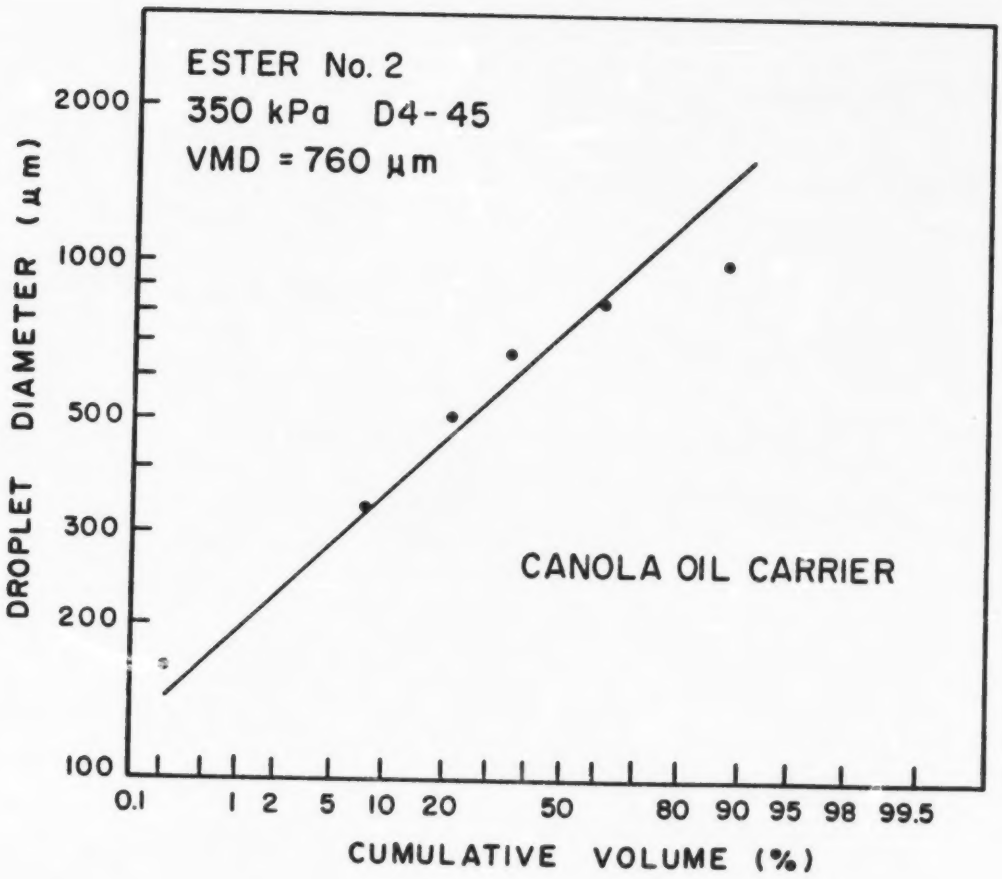
VMD = 770 µm
CANOLA OIL CARRIER
DROPLET DIAMETER (µm)
2000
1000
500
300
200
100
0.1
1
2
5
10
20
50
80
90
95
98
99.5
CUMULATIVE VOLUME (%)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CANOLA OIL CARRIER
DROPLET DIAMETER (µm)
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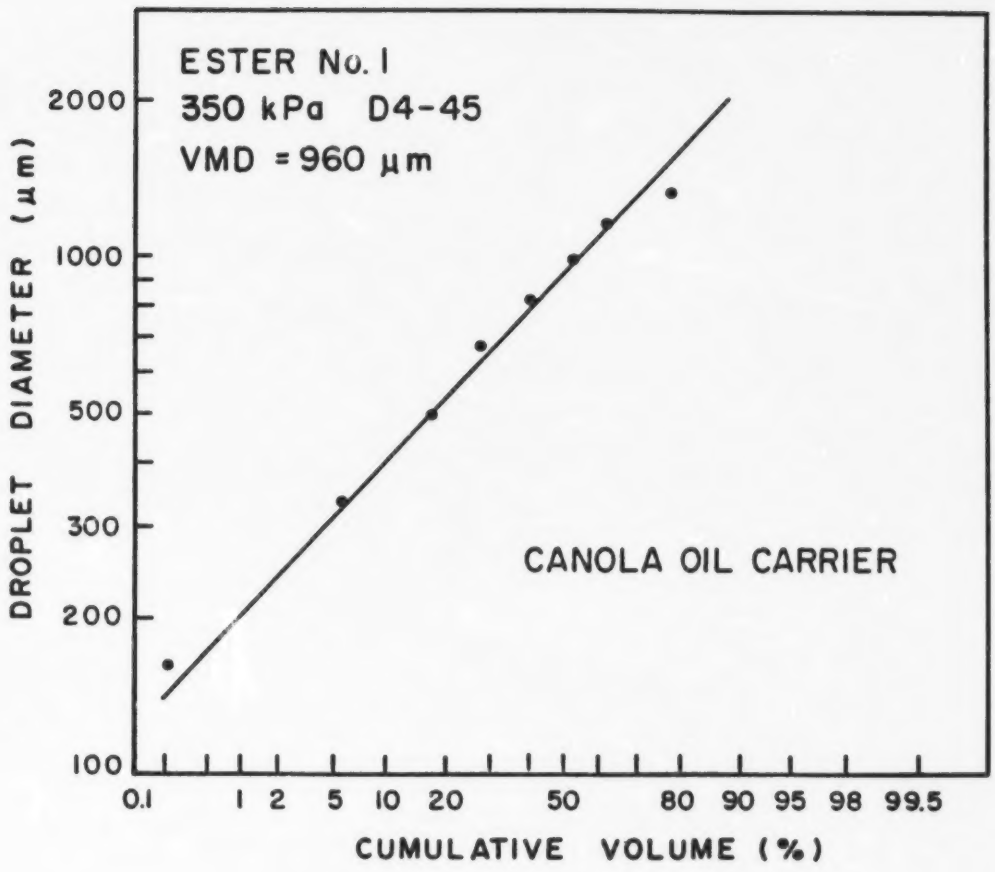
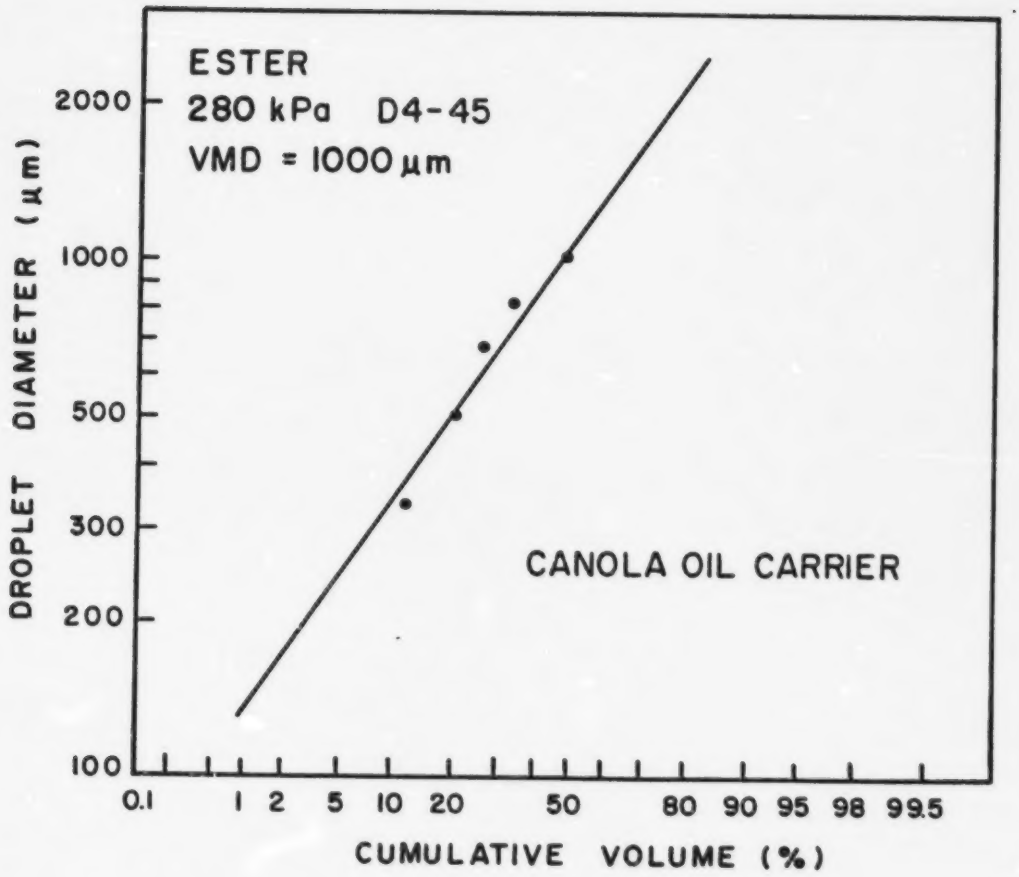
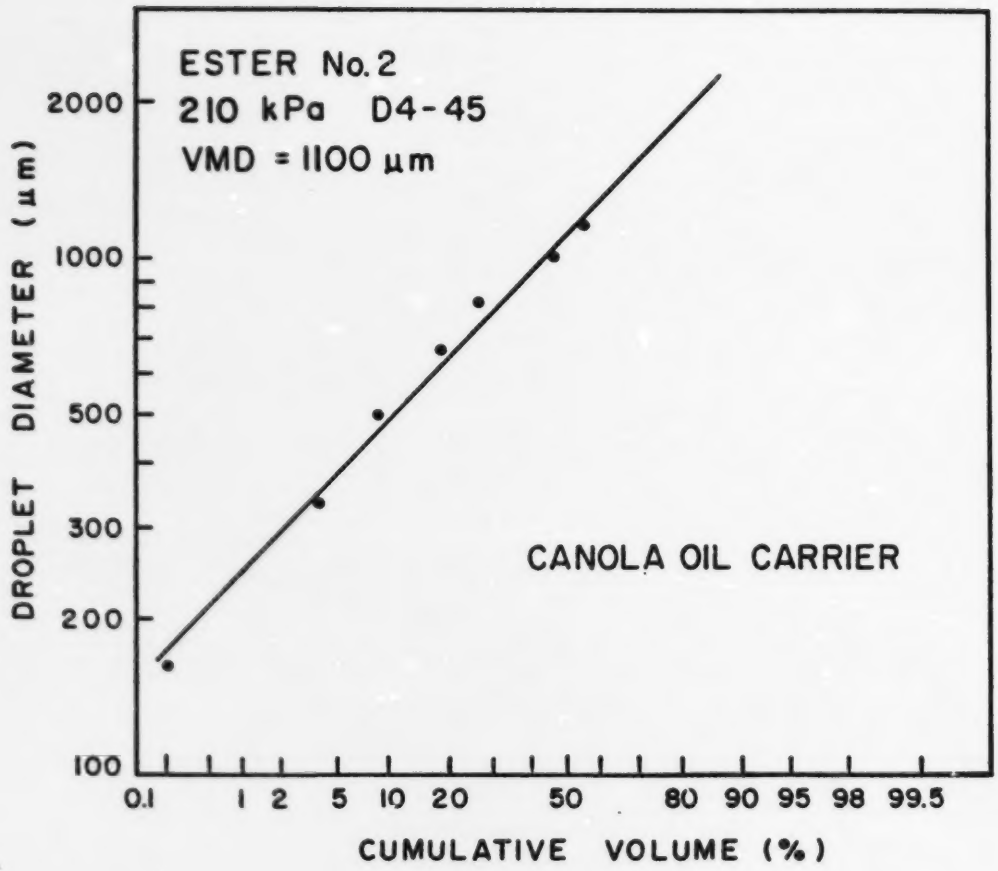
1000
500
300
200
100
0.1
1
2
5
10
20
50
80
90
95
98
99.5
CUMULATIVE VOLUME (%)


ESTER No. 1
350 kPa D4-45
VMD = 960 µm
CANOLA OIL CARRIER
DROPLET DIAMETER (µm)
2000
1000
500
300
200
100
0.1
1
2
5
10
20
50
80
90
95
98
99.5
CUMULATIVE VOLUME (%)


ESTER
280 kPa D4-45
VMD = 1000 µm
CANOLA OIL CARRIER
DROPLET DIAMETER (µm)
2000
1000
500
300
200
100
0.1
1
2
5
10
20
50
80
90
95
98
99.5
CUMULATIVE VOLUME (%)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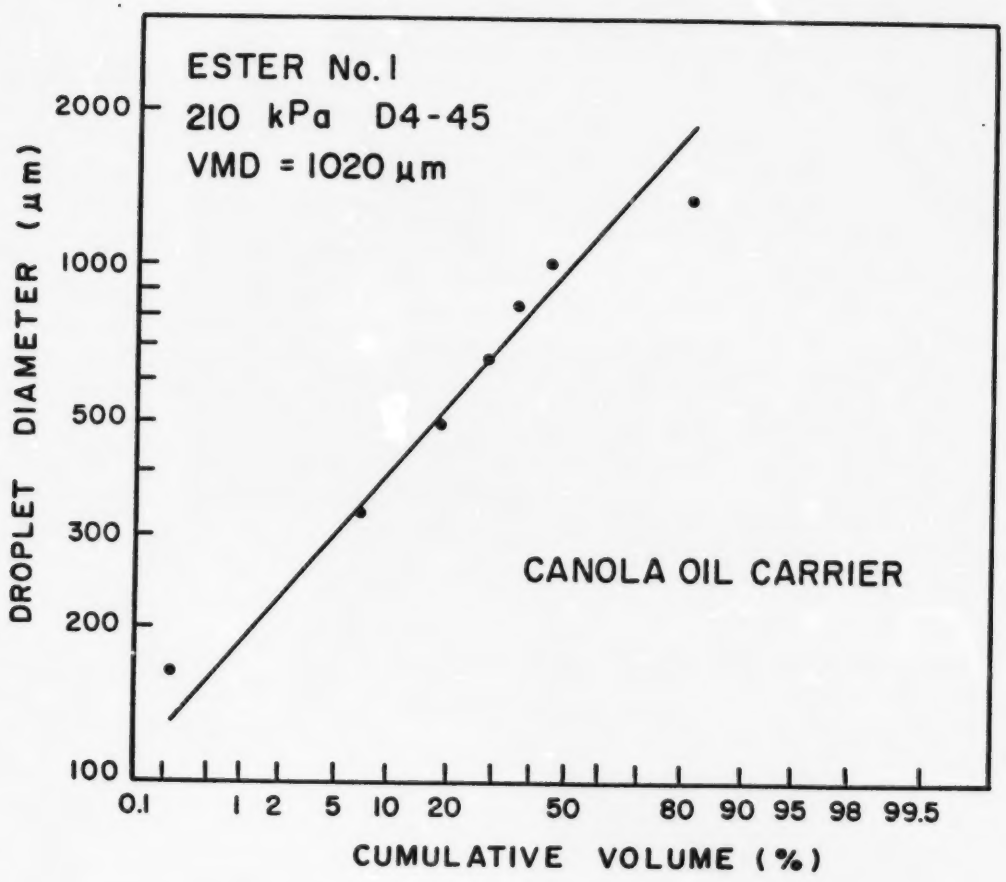
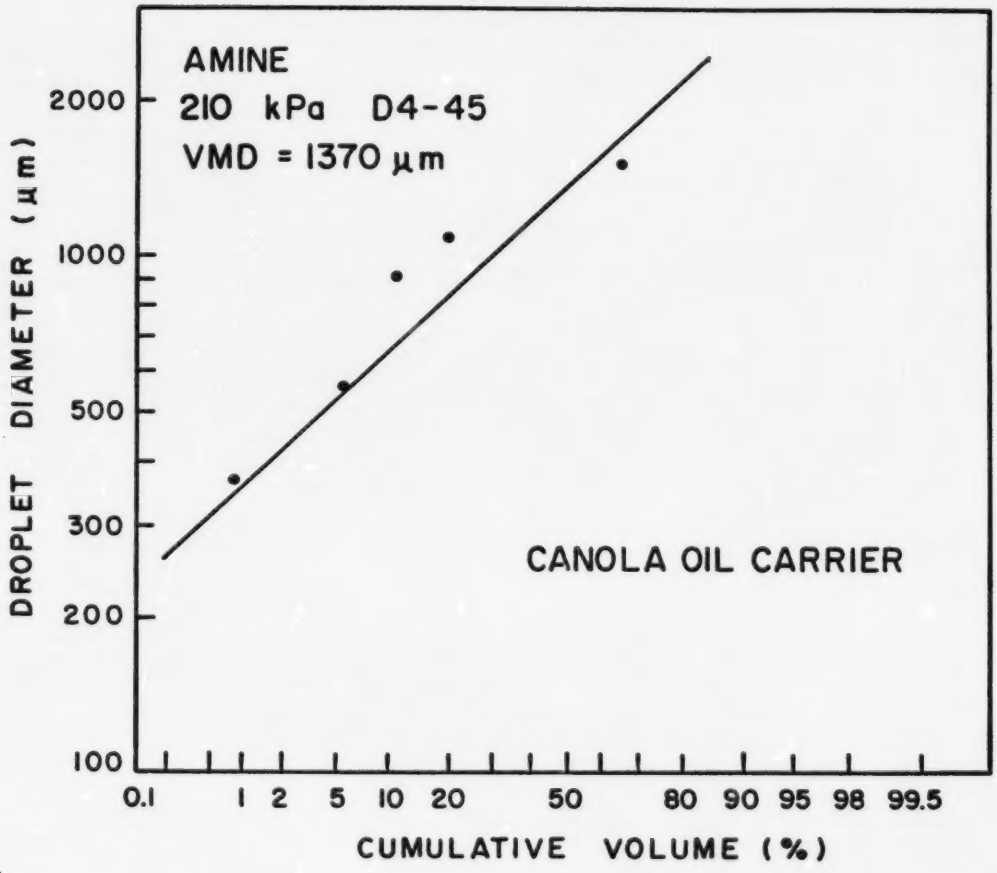
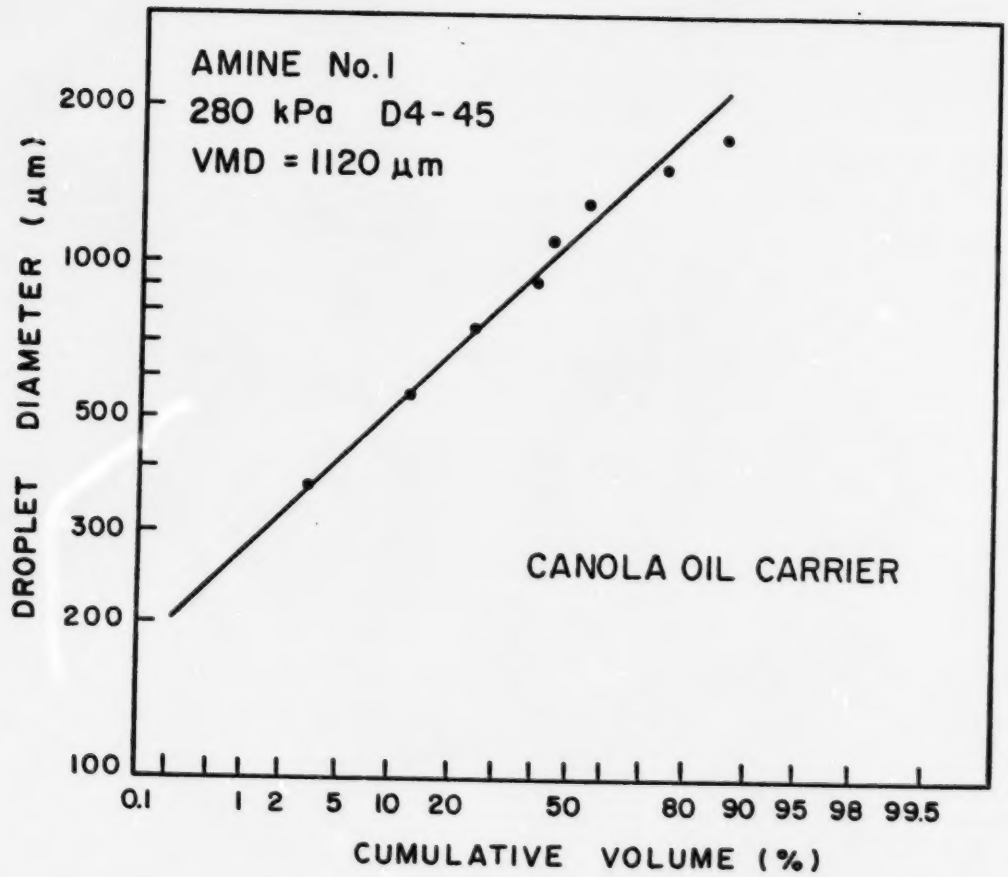
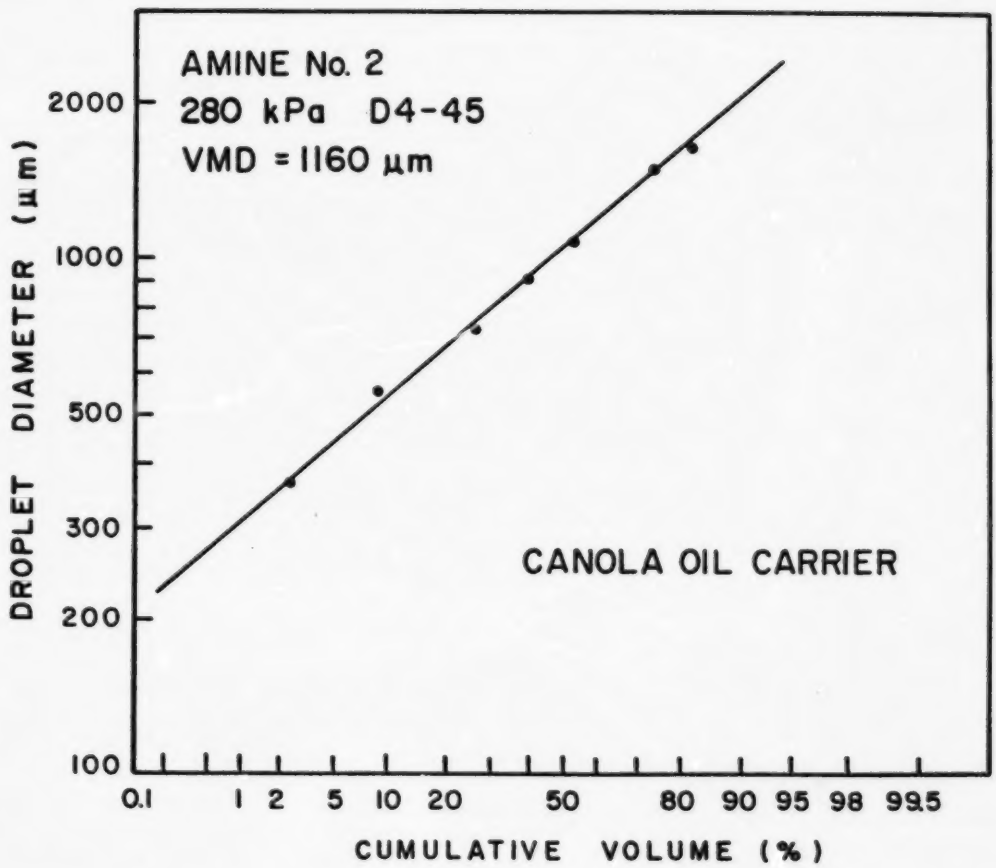
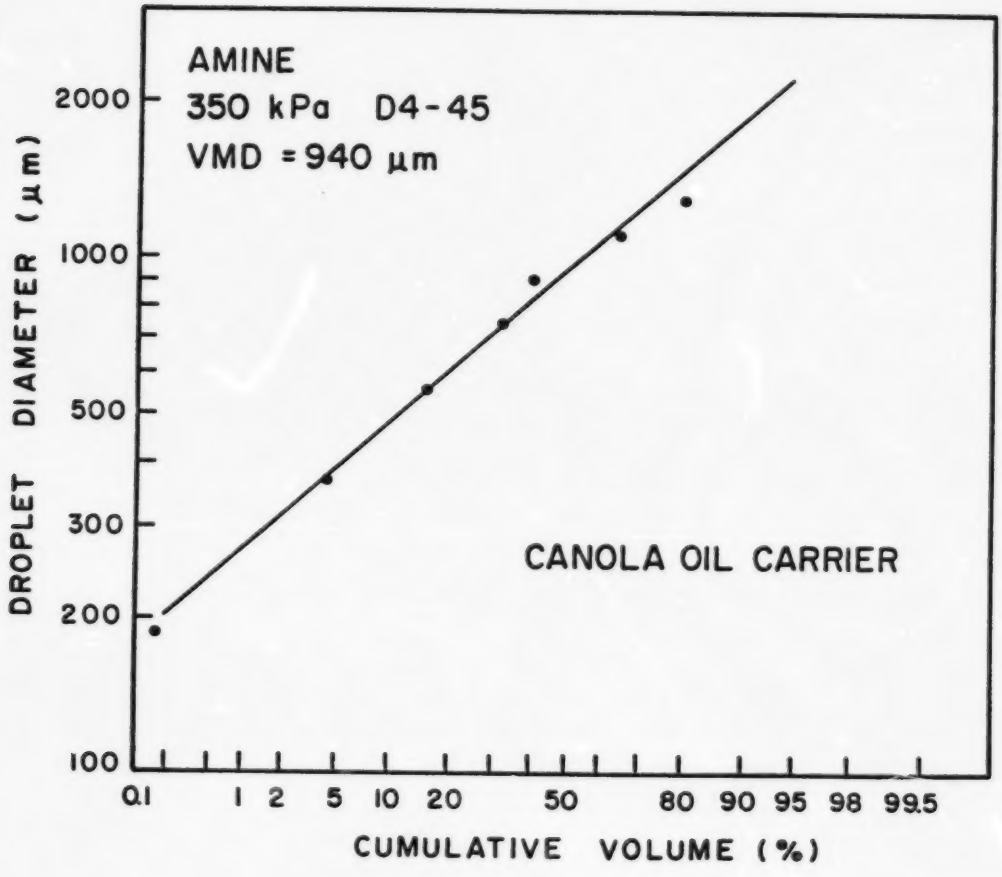
DROPLET DIAMETER (µm)
2000
1000
500
300
200
100
0.1
1
2
5
10
20
50
80
90
95
98
99.5
CUMULATIVE VOLUME (%)

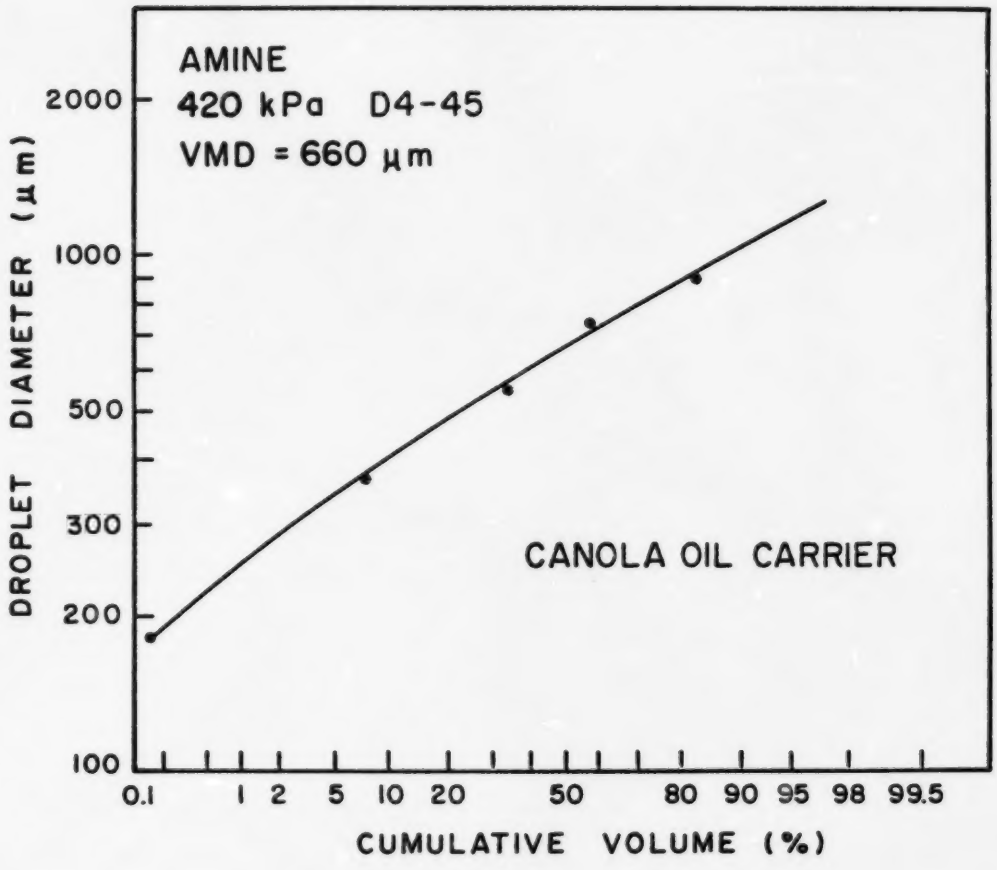

ESTER No.1
210 kPa D4-45
VMD = 1020 µm
CANOLA OIL CARRIER
DROPLET DIAMETER (µm)
2000
1000
500
300
200
100
0.1
1
2
5
10
20
50
80
90
95
98
99.5
CUMULATIVE VOLUME (%)

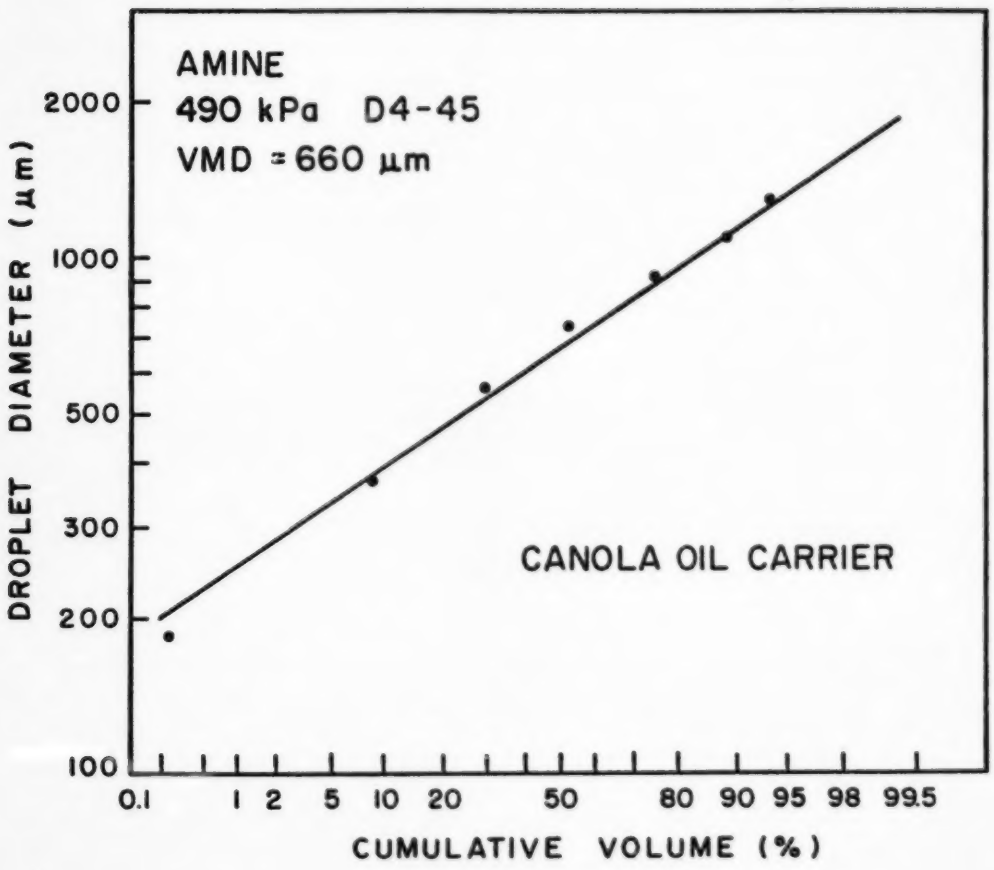

AMINE
210 kPa D4-45
VMD = 1370 µm
CANOLA OIL CARRIER
DROPLET DIAMETER (µm)
2000
1000
500
300
200
100
0.1
1
2
5
10
20
50
80
90
95
98
99.5
CUMULATIVE VOLUME (%)

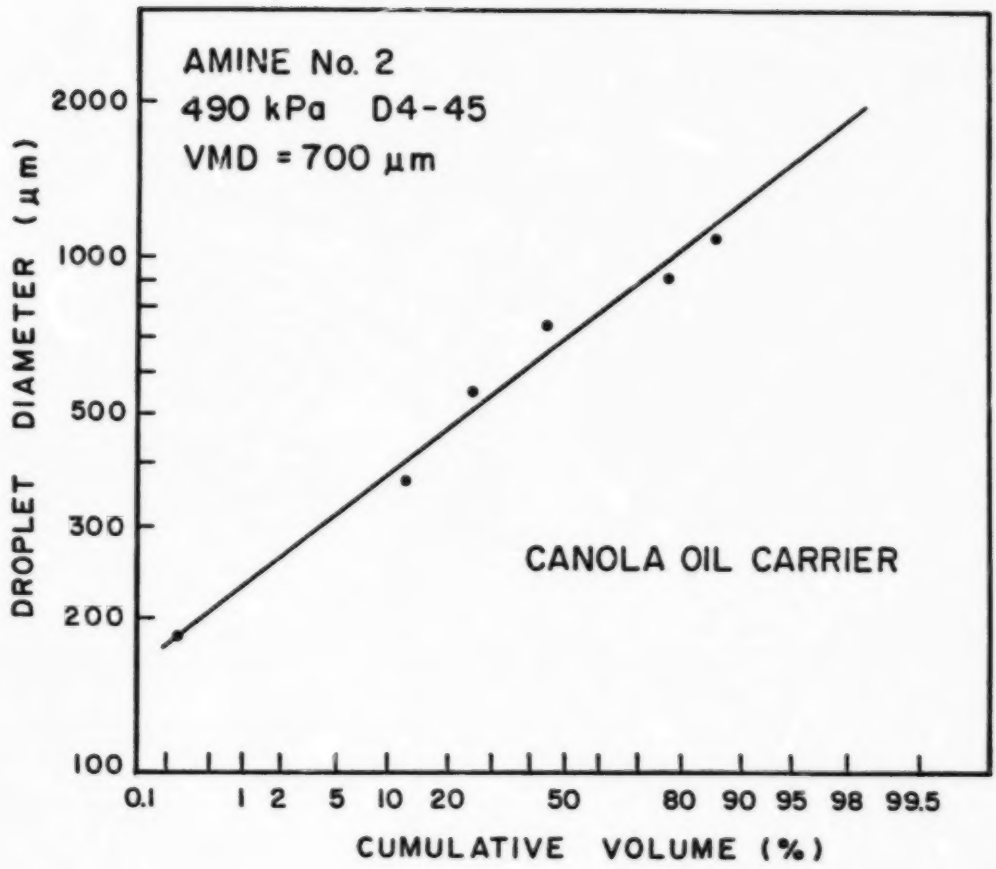

AMINE No.1
280 kPa D4-45
VMD = 1120 µm
CANOLA OIL CARRIER
DROPLET DIAMETER (µm)
2000
1000
500
300
200
100
0.1
1
2
5
10
20
50
80
90
95
98
99.5
CUMULATIVE VOLUME (%)

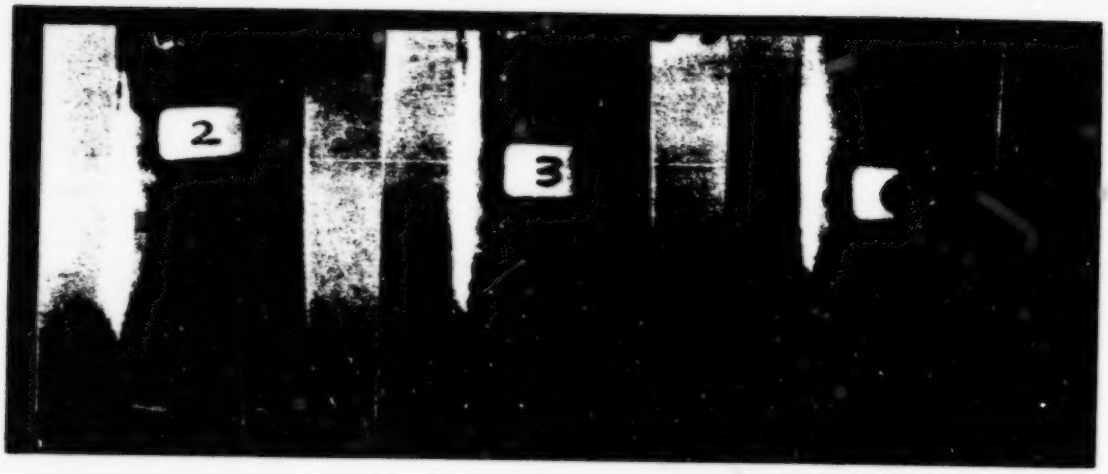

AMINE No. 2
280 kPa D4-45
VMD = 1160 µm
CANOLA OIL CARRIER
DROPLET DIAMETER (µm)
2000
1000
500
300
200
100
0.1
1
2
5
10
20
50
80
90
95
98
99.5
CUMULATIVE VOLUME (%)


AMINE
350 kPa D4-45
VMD = 940 µm
CANOLA OIL CARRIER
DROPLET DIAMETER (µm)
2000
1000
500
300
200
100
0.1
1
2
5
10
20
50
80
90
95
98
99.5
CUMULATIVE VOLUME (%)

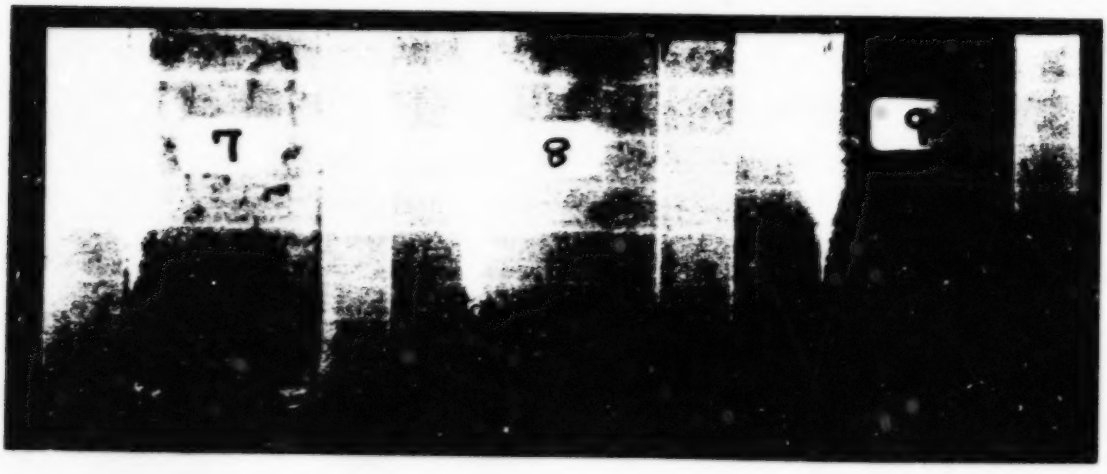

AMINE
420 kPa D4-45
VMD = 660 µm
CANOLA OIL CARRIER
DROPLET DIAMETER (µm)
2000
1000
500
300
200
100
0.1
1
2
5
10
20
50
80
90
95
98
99.5
CUMULATIVE VOLUME (%)


AMINE
490 kPa D4-45
VMD = 660 µm
CANOLA OIL CARRIER
DROPLET DIAMETER (µm)
2000
1000
500
300
200
100
0.1
1
2
5
10
20
50
80
90
95
98
99.5
CUMULATIVE VOLUME (%)


AMINE No. 2
490 kPa D4-45
VMD = 700 µm
CANOLA OIL CARRIER
DROPLET DIAMETER (µm)
2000
1000
500
300
200
100
0.1
1
2
5
10
20
50
80
90
95
98
99.5
CUMULATIVE VOLUME (%)



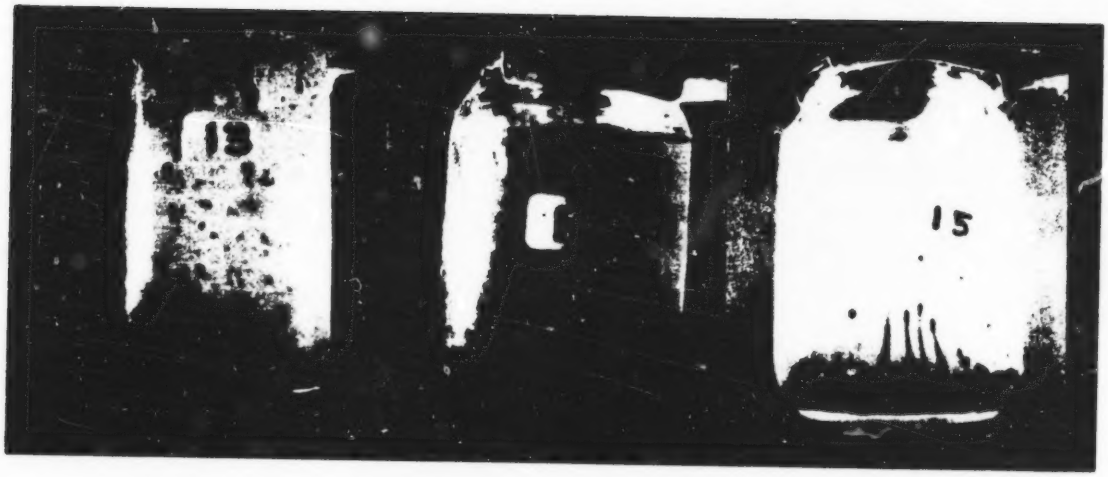
SAMPLE NO.	CANOLA OIL (ml)	2,4-D AMINE (ml)	ATMUL 124 (mg)
2	95	5	100
3	95	5	250
6	70	5	150



SAMPLE NO.	CANOLA OIL (ml)	2,4-D AMINE (ml)	ATMUL 124 (mg)
7	82	5	150
8	94	5	100
9	70	10	250

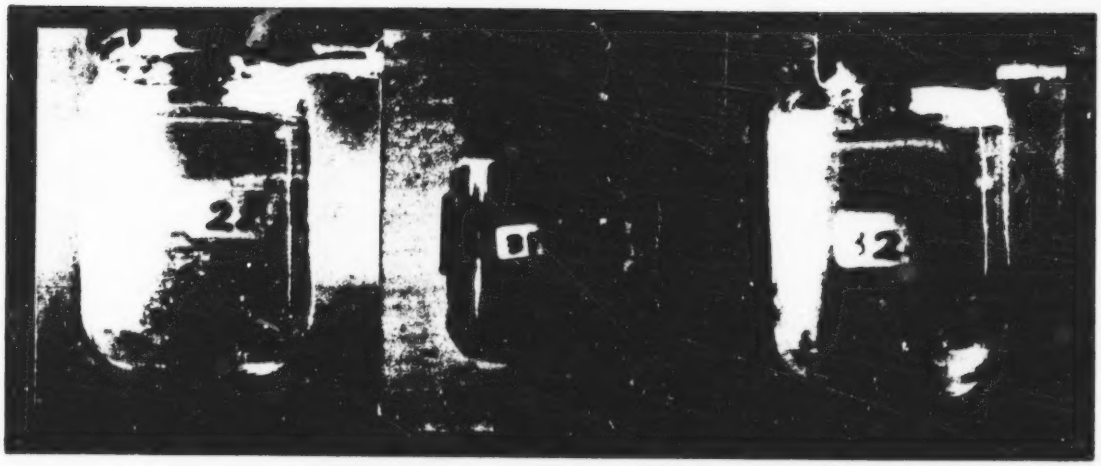
SAMPLE NO.	CANOLA OIL (ml)	2,4-D AMINE (ml)	CANPLUS 129 (ml)
11	45	2.5	3.0
12	90	5	100 Ca soap
17	80	5	15

SAMPLE NO.	CANOLA OIL (ml)	2,4-D AMINE (ml)	CANPLUS 129 (ml)
26	70	5	25



SAMPLE NO.	CANOLA OIL (ml)	2,4-D AMINE (ml)	ADDITIVE (ml)
13	95	5	Ca soap — 50
14	60	5	Multiple
15	95	5	Toluene — 1

SAMPLE NO.	CANOLA OIL (ml)	2,4-D AMINE (ml)	AMMONIUM LIGNOSULPHATE (ml)
25	75	5	20



SAMPLE NO.	CANOLA OIL (ml)	2,4-D ESTER (ml)	ADDITIVE (ml)
22	80	5	Atsurf — 6
31	95	5	No additive
32	89	5	Canplus — 6

SAMPLE NO.	CANOLA OIL (ml)	2,4-D ESTER (ml)	ADDITIVE (ml)
33	85	5	Canplus — 10

SAMPLE NO.	CANOLA OIL (ml)	2,4-D AMINE (ml)	CD-389 (ml)
23	80	5	15
24 (Flip)	70	5	25
24 (Agitation)	70	5	25

SAMPLE NO.	CANOLA OIL (ml)	2,4-D AMINE (ml)	CD-389 (ml)
28	70	5	10

ATKEMIX INC.

Brantford, Ontario N3T 5T2

P.O. Box 1065 Tel. (519) 756-6181

PRODUCT INFORMATION

CANPLUS 129

agricultural surfactant

CANPLUS 129 was developed for use in vegetable oil/surfactant blends designed to be used as activator adjuvants and/or pesticide carriers.

CANPLUS 129 is an effective emulsifier for the most popular vegetable oils available in Canada, namely Canola and soybean oils. Extensive testing has shown that complete solubility in these oils is maintained over a wide range of concentration, time and temperature: see Formulations section below.

Field testing with the triazine and other herbicides has demonstrated the adjuvant functionality of vegetable oil/surfactant blends based on CANPLUS 129: see Field Evaluation section below.

FORMULATIONS

For use as a herbicide adjuvant we recommend evaluation of the following formula:

CD-351:	Vegetable oil	85.0% by weight
	CANPLUS 129	15.0%

For use as a pesticide carrier, we recommend evaluation of the following formula:

CD-353A:	Vegetable oil	94.0% by weight
	CANPLUS 129	6.0%

The above formulations, based on either unrefined Canola oil and soybean oil, maintained their fluidity and homogeneous appearance when subject to temperatures ranging from -25° C to 50° C, including being subjected to 5 freeze-thaw cycles.

Both formulations, when stored for over a year at ambient room temperature, (ca. 22° C.) retained their integrity and emulsifiability.

As expected, superior emulsion stability in aqueous solution is obtained from the 85 + 15 formulations compared to the use lower levels of CANPLUS 129. Slightly superior emulsion stability is obtained from soybean oil based blends compared to the Canola oil equivalent.

cont'd.....

FIELD EVALUATIONS

Atkemix Inc. has field tested the above recommended formulations with several herbicides, and although not yet complete the data shows the 85 + 15 blend to provide similar adjuvant effect to an equal volume of CANPLUS 411* providing the labelled rate of herbicide is applied. At marginal herbicide rates, performance of the vegetable oil based adjuvants appears somewhat inferior to CANPLUS 411. We found no significant control difference between the soybean and Canola oil based adjuvants, nor between refined or unrefined vegetable oil.

Less adjuvant effect is obtained from the use of 6% or 9% surfactant in the vegetable oils. Thus, we recommend the 94 + 6 vegetable oil/surfactant blend primarily as a pesticide carrier. Inclusion of the surfactant is important in enhancing compatibility of the vegetable oil/emulsifiable concentrate, or the dispersion of wettable powder in the oil if the pesticide is formulated in solid form.

When used as a pesticide carrier with hydraulic or rotary (spinning disc) nozzles it may be necessary to use once-refined vegetable oils to ensure freedom from nozzle clogging.

Vegetable oil/CANPLUS 129 blends have been demonstrated to impart improved control with the following pesticides from aqueous diluant:

atrazine on field and sweet corn, and T.R. Canola
cyanazine on field and sweet corn
sethoxydim on Canola
bentazon on soybeans
glyphosate for annual grass control
carbaryl for european corn borer control on peppers

PHYTOTOXICITY

The above mentioned field evaluations showed the above recommended vegetable oil/surfactant blends to cause no significant injury to the growing crop when applied post-emergent as an adjuvant from aqueous diluant. With cyanazine the spray is required to be 'directed' otherwise crop injury will occur; glyphosate not sprayed on growing crops.

No date is currently available on the phytotoxicity of vegetable oil/CANPLUS 129 blends as a non-aqueous pesticide carrier. However, based on U.S. data for related formulations, we anticipate no phytotoxicity problems with labelled quantities of herbicides.

*83% phytobland paraffinic oil + 17% CANPLUS 300

cont'd.....

STORAGE AND HANDLING

CANPLUS 129 is classified as 'relatively harmless' according to the classification of Hodge and Sterner. The product may be mildly irritating to unwashed skin or eyes, but is not a primary sensitizer.

No problems have been encountered to date with this product. However, prolonged contact with the skin could cause defatting, consequently reasonable precautions should be employed in its use such as the wearing of protective gloves.

FIRST AID: In case of contact wash with skin or eye wash with copious quantities of water.

DISPOSAL: Soak up spills with an absorbant and shovel into a waste container. Dispose of waste material in accordance with local pollution guidelines. Wash down spill area with hot water.

REGISTRATION

Neither CANPLUS 129 nor vegetable oil/CANPLUS 129 blend are currently registered for use in Canada under the PCP Act. Thus, CANPLUS 129 is being offered for evaluation purposes only.

When sufficient data has been collected, it is anticipated that registration will be received for the use of vegetable oil/CANPLUS 129 blends for application to growing crops.

TYPICAL PROPERTIES

Classification	Non-ionic surfactant
Appearance at 25° C.	Amber colour liquid
Specific gravity at 25° C.	Approx. 1.01
Viscosity at 25° C.	Approx. 200 cps
Pour point	Below -18° C.
Flash point	Above 149° C.
Solubilities	Soluble in paraffinic oil, Canola oil, soybean oil and most aromatic solvents; dispersible in water.

STANDARD SPECIFICATIONS

Acid number	12 max.
Water	0.5% max.

cont'd.....

DEVELOPMENTS

Atkemix Inc. has an on-going development program to investigate the potential of vegetable oils for agricultural end-uses. As new data or information becomes available we shall appropriately revise this Information Bulletin and endeavour to keep all interested persons informed.

For more information on CANPLUS 129 or on any of our ATLOX, ATPLUS or CANPLUS agricultural surfactants, contact Atkemix Inc., P.O. Box 1085, Brantford, Ontario. For faster service, phone (519) 756-6181 or Telex 061-81240.

ATKEMIX INC.
Brantford, Ontario N3T 5T2
P.O. 1035 / Tel. (519) 756-6181

PRODUCT INFORMATION

ATSURF 205

sorbitan mono-oleate

General Characteristics

Classification	Nonionic surfactant
Form @ 25 deg. C.	Reddish brown liquid
Specific Gravity @ 25 deg. C./25 deg. C.	Approx. 1.0
Viscosity @ 25 deg. C.	Approx. 1200 cps
Flash Point	Above 149 deg. C.
Pour Point	Approx. -18 deg. C.
HLB Number*	4.3

Solubilities (5%)

Soluble in most mineral oils, vegetable oils, lower alcohols, and chlorinated solvents; insoluble in water and lower glycols.

*Hydrophile-lipophile balance rating.

Standard Specifications

Acid Number	8.0 max.
Saponification Number	135-150
Hydroxyl Number	180-210
Water, %	1.0 max.

5/83

ATKEMIX INC.

Brantford, Ontario N3T 5T2

P.O. Box 1685 Tel (519) 756-6181

PRODUCT INFORMATION

ATMUL® 124

Description

Mono- and diglycerides

General Characteristics

Classification	Food emulsifier
Appearance @ 25 deg. C.	Ivory white beads
Melting point	Approx. 62 deg. C.
Hydroxyl value	Approx. 245
Odor and taste	Bland
Total monoglycerides (alpha and beta forms)	Approx. 62%
Flash point	Above 149 deg. C.
Fire point	Above 149 deg. C.
HLB number*	3.5

*Hydrophile-lipophile balance rating

Solubilities

(a) Soluble above its melting point in isopropyl alcohol, vegetable oils, and mineral oil.

(b) Insoluble in water and propylene glycol.

Standard Specifications

Monoglycerides (alpha form), %	52 min.
Free glycerin, %	1.5 max.
Free fatty acid (as oleic), %	2.5 max.
Acid value	5.0 max.
Water, %	1.5 max.
Residue on Ignition, %	0.1 max.
Heavy metals (as Pb), ppm	10 max.
Arsenic (as As), ppm	3 max.
Saponification value	164 - 176

Conforms to Canadian Food Regulations and Food Chemicals Codex Specifications for mono- and diglycerides.

Revised Jan. 1983